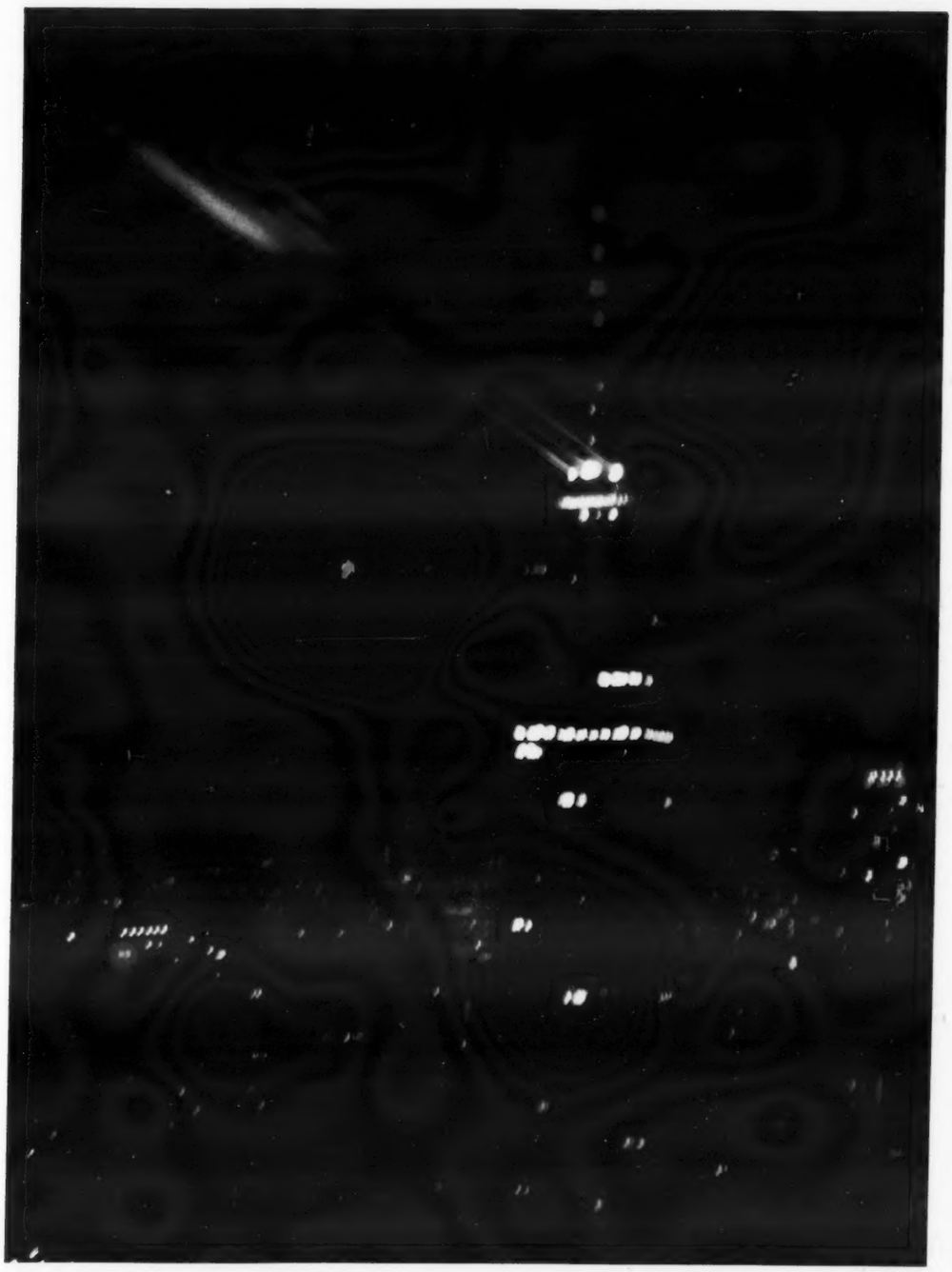
INTERAVIA

REVIEW OF WORLD AVIATION



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Safe Journeys, Safe Landings

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Review of World Aviation

Volume XI | No. 7 | July 1956

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Front cover:
On top of New York's Empire State Building burn the most powerful searchlights in the world (2,000,000,000 candle power). Visible from a distance of 300 miles, they help guide aircraft to Idlewild, Newark, La Guardia and Teterboro airports. Incidentally, Senior Vice-President of the Empire State Building Corporation is Fred M. Glass, one of the United States' most experienced air safety experts, whose views on U.S. aviation facilities are outlined in this issue.

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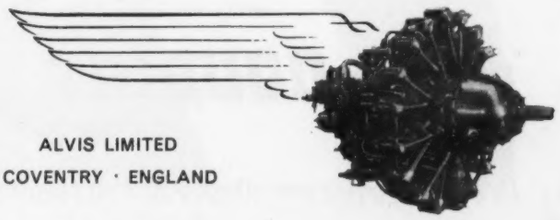

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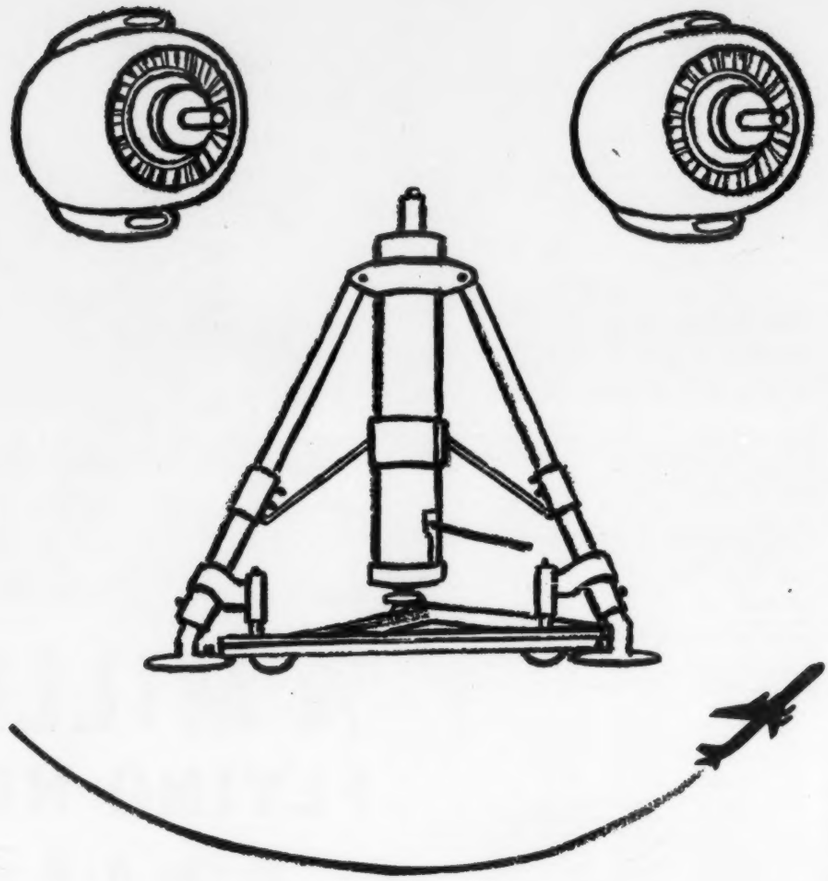

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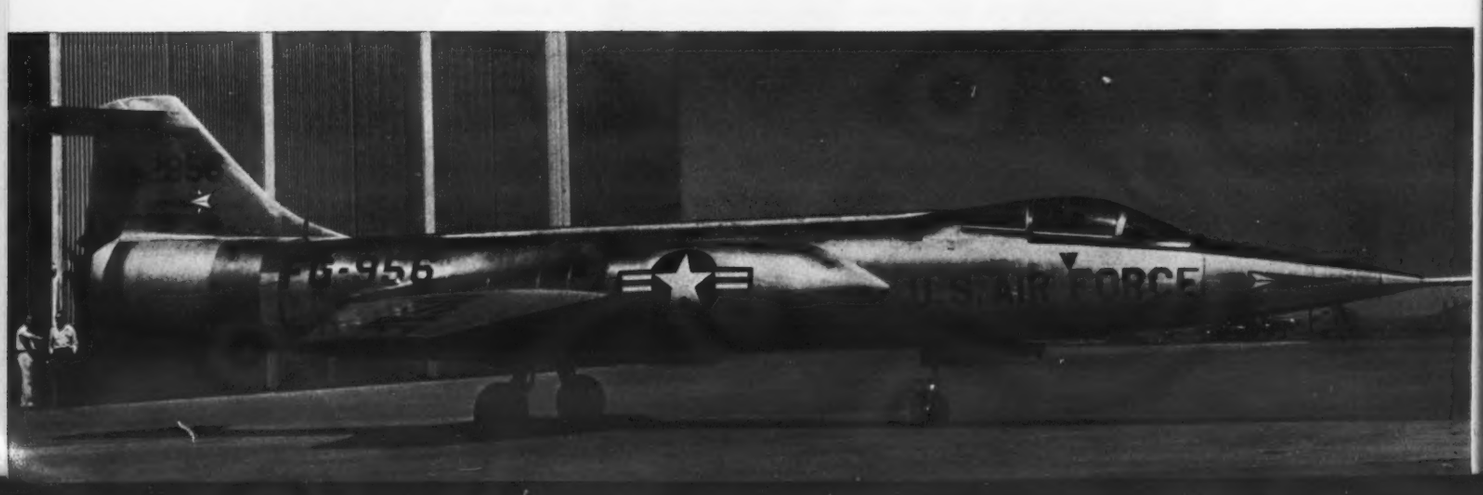

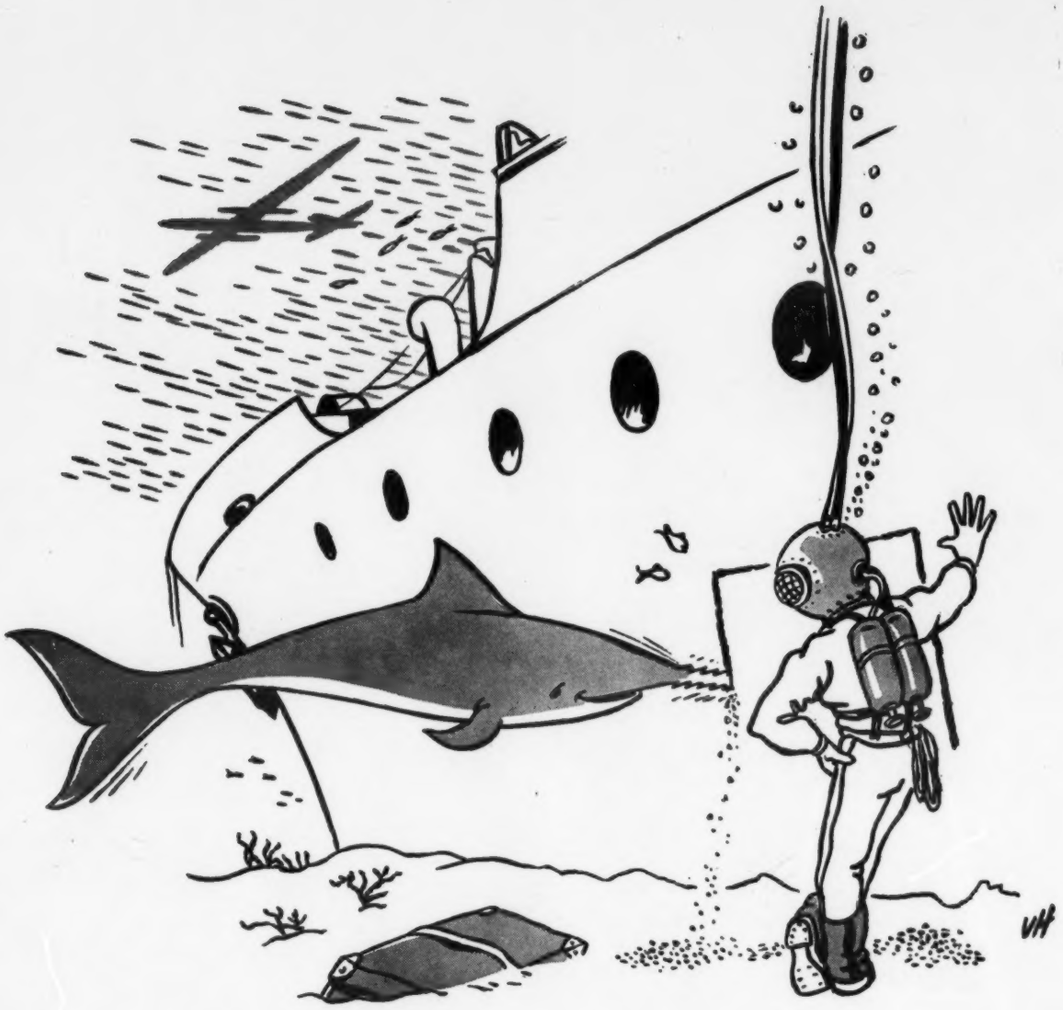

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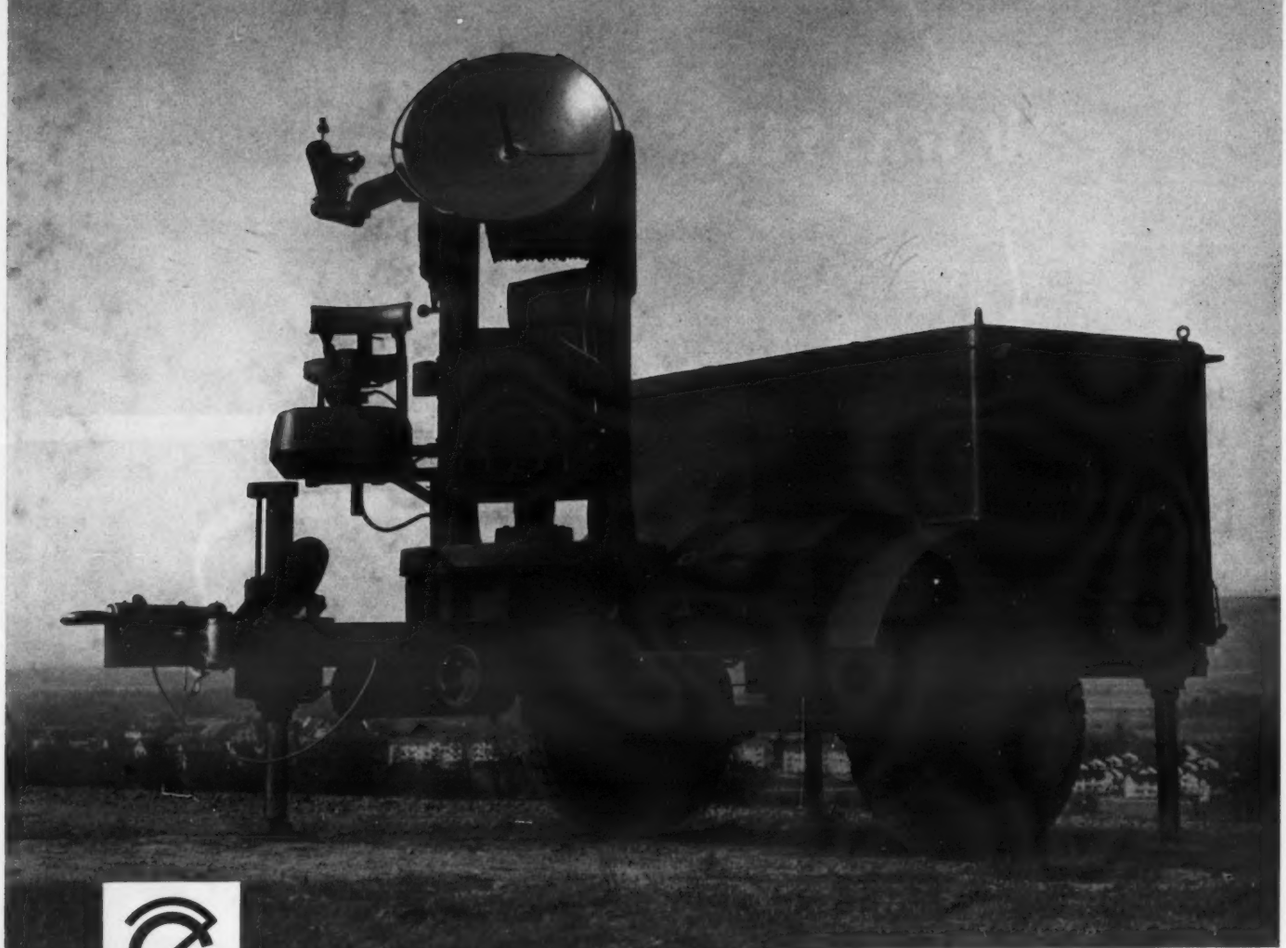

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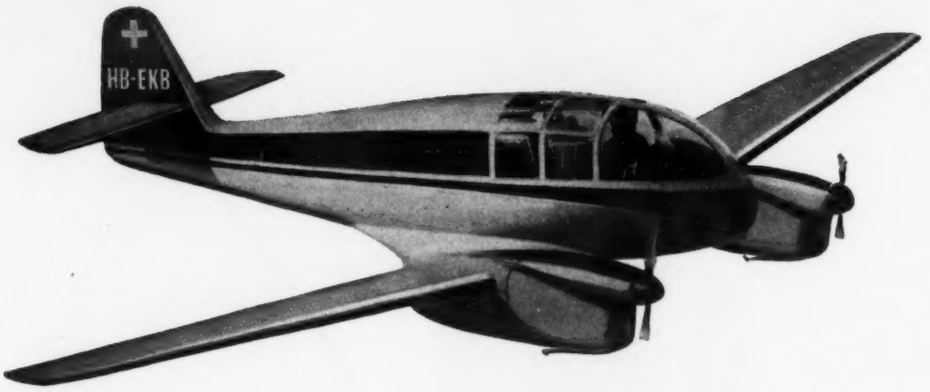

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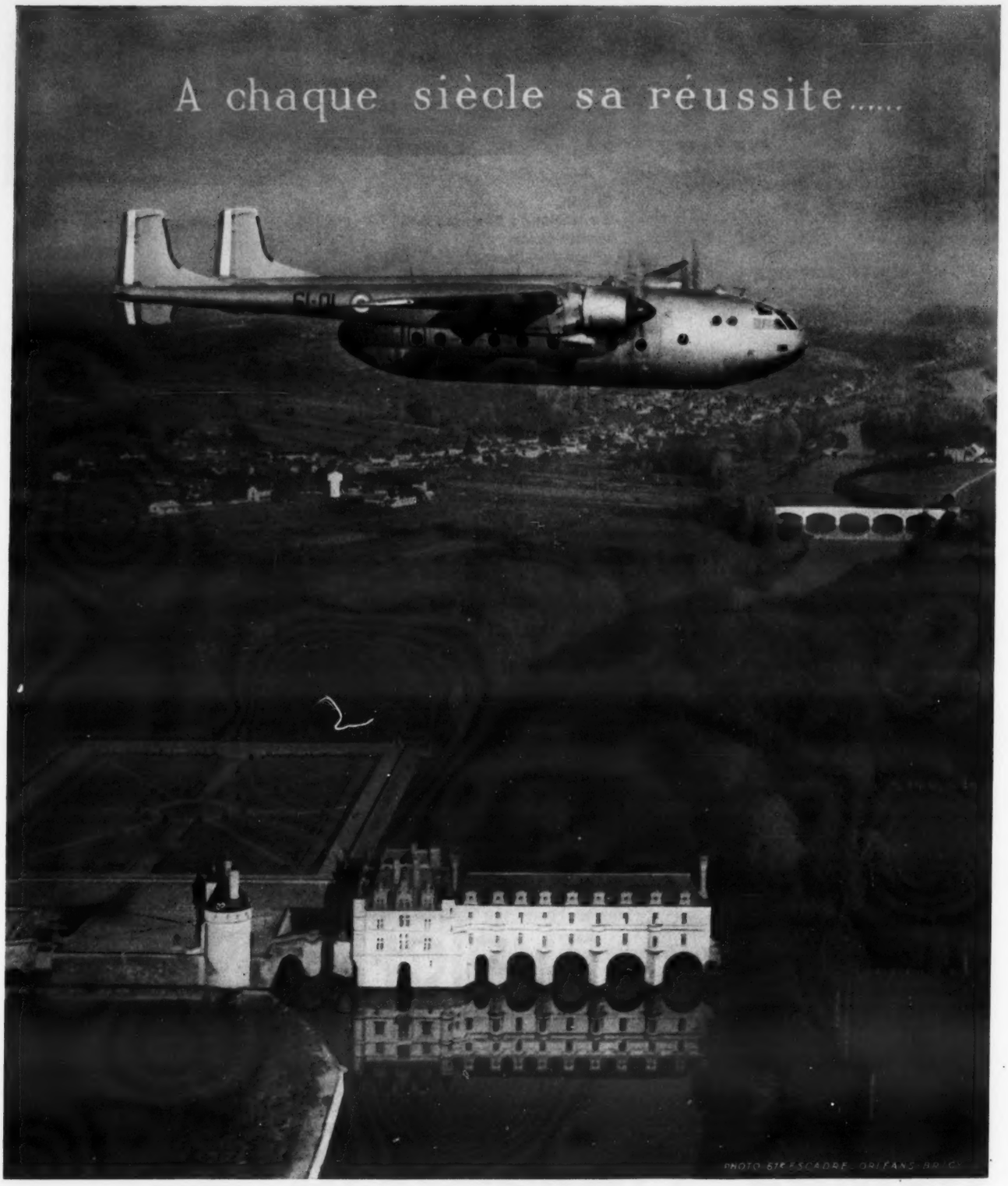

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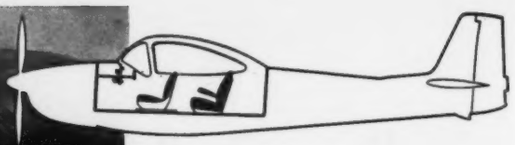

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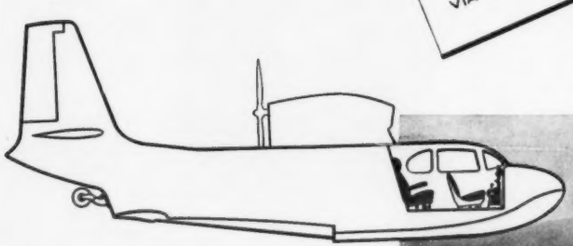

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Maintenance Award

This Award will be made each year for the best idea, proposal, or design leading to the solution of an aircraft maintenance problem. It may embrace a technique, design, device or instrumentation in the tear-down, build-up and/or testing of aircraft engines and accessories. A suitably enscribed plaque will be presented to the winning contribution late in 1956. An honorarium of $500 will be given with the Award.

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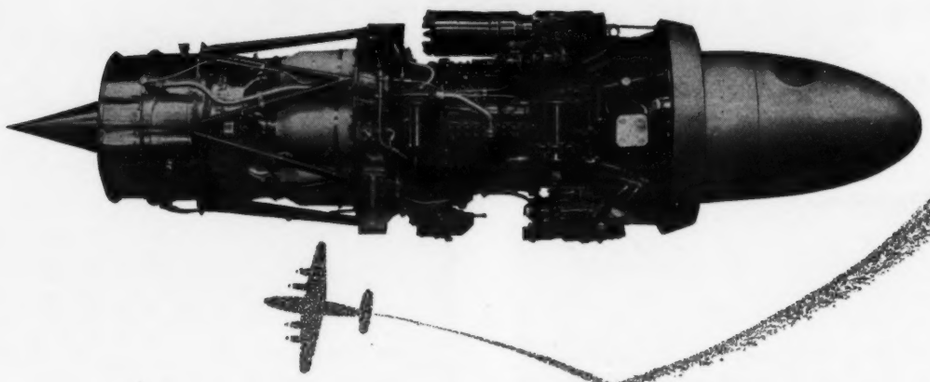

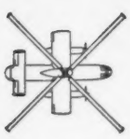

ELAND A Convair 340 aircraft converted to *Eland* engines will be on demonstration flights in Europe and the U.S. during this year. Another aircraft powered by *Elands* is the Elizabethan, converted for freighter evaluation. Napier *Elands*, fitted with auxiliary compressors for the tip-powered rotor system, will be mounted in Fairey's new large transport helicopter, the Rotodyne.

ORYX Two Napier *Oryx* engines are being mounted in the new Percival P74. Napier worked with Hunting Percival in the development of the *Oryx*, a 750-825 gas h.p. turbo-gas-generator which has been Type Tested at 780 g.p.h. This new Napier power unit eliminates all mechanical transmission.

GAZELLE The Gazelle is another Napier engine which is going places. The first helicopters to be powered by Gazelles are the Westland Wessex and the twin-rotor Bristol 192. The engine can be mounted in any position, vertically or horizontally and can be directly connected to the rotor head, providing mechanical transmission in its simplest form.

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Boeing cabin mock-up designed for jet-age travel

This life-size mock-up of the Boeing Jet Stratoliner cabin was designed to provide an interior as modern and advanced as the 600-mile-an-hour performance of the aircraft itself.

Ninety-eight standard seats, with 40-inch spacing, are provided, along with lounges forward and aft for 10 extra passengers. The seats, in two- and three-abreast sections, are set in floor tracks. This feature makes possible quick changes of seat spacing, in one-inch stages, and permits four-, five-, and six-abreast seating in any desired combination. A complete changeover requires only an hour.

Because there are twice as many windows in this cabin as in any airplane now flying, there is never a problem of seats out of phase with windows. This arrangement also gives all passengers, even in innermost aisle seats, an unobstructed window view.

Reading-light and forced-air controls, "seat belt" signs, and an individual speaker are located in units suspended from the hat rack. These units, which tend to compartmentalize the cabin, can be snapped out for inspection or repair. They are infinitely adjustable in location to conform to any seating arrangement. All ceiling and wall surfaces are in washable plastic, in panels that can be pulled out, or snapped back, in minutes, greatly speeding up structure inspection and maintenance.

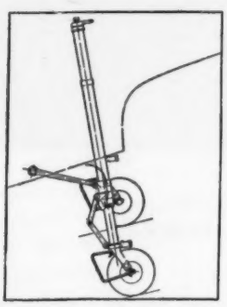
These features – and many, many more – will bring jet-age advantages to both operators and passengers. Eight major American and European airlines have already ordered fleets of Boeing jets: Air France, American Airlines, Braniff International Airways, Continental Air Lines, Lufthansa-German Airlines, Pan American World Airways, Sabena Belgian World Airlines and Trans World Airlines.

This Boeing is the only American jet transport proven by a flight-tested prototype. It benefits, too, from Boeing's unique background of experience in designing, building and flying more large, multi-jet aircraft than any other company in the world.

BOEING

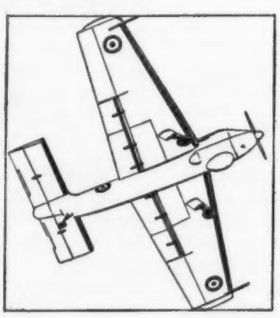
Coastal patrol — *Seamew* patrol

Because of its low landing speed, the Seamew can alight in an extremely small area. Tyre sizes can be easily changed to suit terrain.

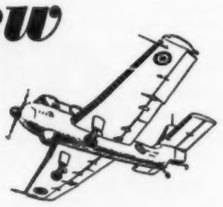


The two position tail wheel gives the advantages of a tricycle undercarriage layout for landing, while retaining the desirable features of the normal undercarriage for take-off.

Seamew—a tough, economical, all-weather submarine hunter. From an emergency coastal airstrip the Seamew can be airborne in a short distance to operate a wide-ranging patrol. It can conduct a maritime search with up-to-date radar equipment and use a variety of weapons to effect a kill. However rough-and-ready the airstrip, it can land back safely — with its low stalling and landing speeds and fixed, rugged, shock-absorbing undercarriage.



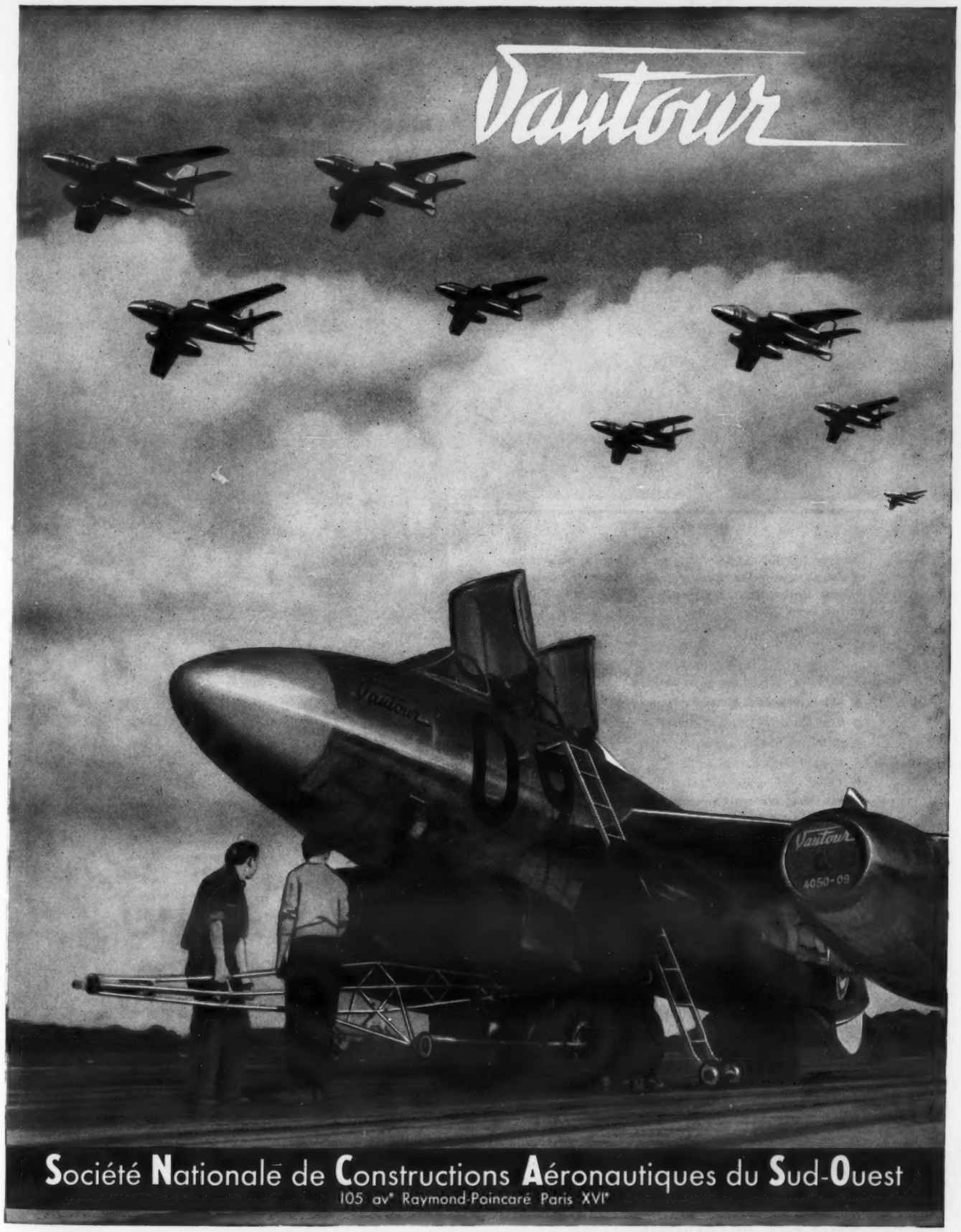
The *Short* answer is the *Seamew*



Generous flap surfaces contribute to the very low stalling and landing speeds. The Seamew is easy to fly and exceptionally manœuvrable.

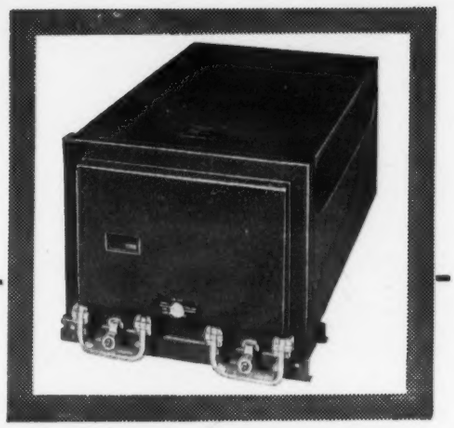
READY FOR SERVICE WITH THE ROYAL NAVY

Short Brothers & Harland Ltd., Queens Island, Belfast, N. Ireland. The first manufacturers of aircraft in the world


Vautour
Vautour
4050-09
Société Nationale de Constructions Aéronautiques du Sud-Ouest
105 av^e Raymond-Poincaré Paris XVI^e

MARCONI SELF-TUNING MULTI-CHANNEL HF COMMUNICATION EQUIPMENT TYPE AD307

Pilot-operated radio telephony



The type AD 307 has been designed to meet the requirements of international airline operators. Full frequency coverage is coupled with extreme simplicity of operation. Its features include:

- **Automatic frequency changing with self-tuning circuits throughout.**
- **Up to 200 crystal controlled channels.**
- **Valves replaceable by standard American types.**
- **Remote-control from two alternative positions.**
- **Self-tuning feature eliminates the need for skilled adjustment.**
- **100-120 watts on telephony.**
- **Choice of carbon or electro-magnetic (including noise-cancelling) microphones.**
- **Designed for use with DC or AC aircraft systems.**
- **Plug-in unit construction is employed for easy servicing.**

More than forty Airlines and twenty Air Forces fit Marconi air radio equipment. Marconi airport installations are in use throughout the world.

Illustrations: *(Top)* Power Amplifier Unit. *(Centre)* Drive and Receiver Unit. *(Left)* Modulator and Power Unit. Not shown is the automatic Aerial Tuning Unit.

Lifeline of Communication

MARCONI

Airport and Aircraft Radio Systems

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

LINK jet simulators will train UNITED AIRLINES DC-8 pilots and crews

Link Aviation, Inc. has been selected by United Airlines to produce their first jet simulator for the new Douglas DC-8 jet transport. Like Douglas Aircraft Company, United also chose Link to develop this important training equipment, so that pilots and crews would have the most realistic jet flight conditions possible.

By reproducing the flight characteristics and the crew compartment of the DC-8 exactly, the Link electronic simulator will make it possible for United personnel to "fly" on the ground in conditions duplicating every detail encountered in the air. Crew coordination, radio procedures, landings and takeoffs, emergency conditions—all can be practiced.

Once again, Link provides the surest and most economical way to prepare flight crews for America's newest aircraft . . . helping to make tomorrow's flight better and safer than ever before.

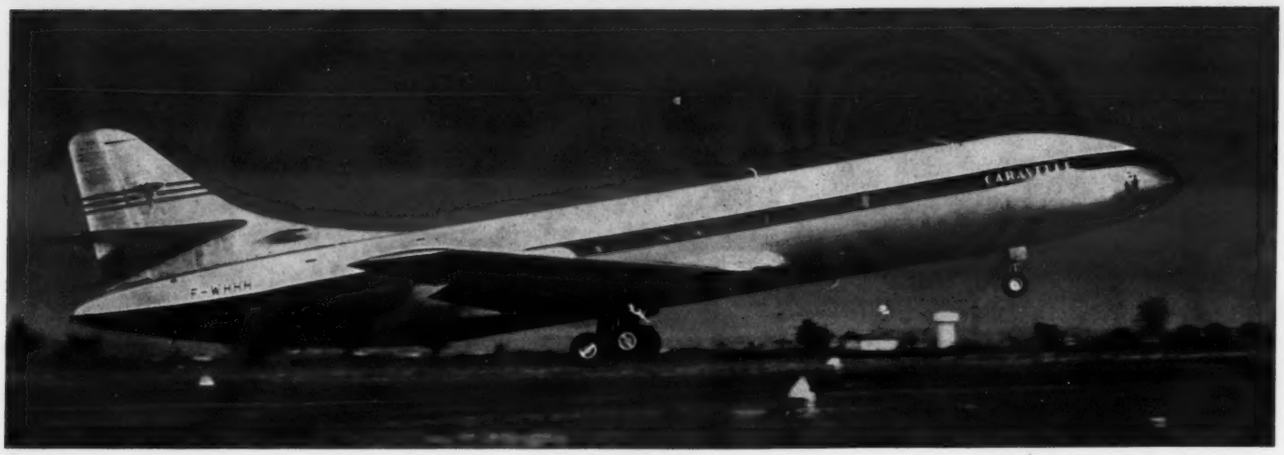
Pioneer and World's Leading Producer of Flight Simulators

LINK AVIATION, INC.

BINGHAMTON, NEW YORK

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.

THIS AIRCRAFT OF TOMORROW ...



... USES TODAY'S GROUND ORGANIZATION

THE TWIN-JET "CARAVELLE" IS THE MEDIUM-RANGE AIRCRAFT OF TOMORROW

because :

- Its 465 m.p.h. cruising speed offers passengers the substantial saving in time they desire;
- Payload is 70 passengers or 15,400 lbs.;
- "Hourly transport capacity"—more than 32,500 passenger-miles—is double that of the present conventional medium-stage aircraft;
- Only half as many aircraft needed for the same traffic, hence much less capital invested;

And the cost per seat-mile is the lowest in the world.

THE TWIN-JET "CARAVELLE" USES TODAY'S GROUND ORGANIZATION

because :

Under standard regulation conditions, at a weight of 90,000 lbs.:

- It takes off normally in 1,490 yards;
- Acceleration-stop distance is 1,960 yards and landing distance 1,200 yards.

Thus the "CARAVELLE" can use existing airports throughout the world despite the fact that two-thirds of them have runways less than 2,200 yards long

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SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES DU SUD-EST

6 Avenue Marceau PARIS 8ème

If the Airline Industry is to solve the growing problem of traffic congestion with its economic penalties, more efficient use of airspace is imperative. The solution, close lateral separation of aircraft, can be provided by Decca—the only navigational aid with the requisite accuracy and coverage at all altitudes.

EN ROUTE Decca allows any pre-determined track to be maintained precisely, and ETAs to be calculated easily, and as often as needed.

IN TERMINAL AREAS the pictorial presentation of the Decca Flight Log allows existing procedures to be maintained with great accuracy and ease. Trials at various European airports have proved beyond question that traffic patterns based on Decca can solve the control problem for both pilot and control officer.

Close lateral separation with **DECCA** *avoids traffic delays... cuts operational costs*

Where drama is out of place

Wind-tunnels, computers, slide rules and test-rigs are all very well, but the only final test of an aeroplane is to fly it.

It does not need vast equipment to work out in advance how far, fast and high an aeroplane can be expected to fly, but not even the resources of our research establishment at Warton can precisely predict *how* it will do these things. The final verdict must come from the test pilot who flies it, backed up by the records of the instruments carried on every flight.

Ingeniously compact and versatile though these instruments are, there is never room enough to record at one time all you want to find out. Planning has to begin long before the first flight of the first prototype. Thereafter every single flight has a planned purpose, though there must always be enough flexibility about the plan to let unexpected findings be explored.

But whatever the instruments say, the last word lies with the test pilot. Unless an aeroplane does all it has to do in a way that is acceptable to the human being inside it, it might as well never have been built.

The job of the test pilot is one of great skill, extreme concentration and much less glamour than the films would have us believe. And however lonely his job may seem, he is very much part of a team—the team that has been working so hard and so long and so objectively to see that (in his own words) he has no moments of drama.

Design starts from an attitude of mind

QUEEN'S HOUSE, KINGSWAY, LONDON, W.C.2

Partners in Progress with Marconi's and Napier in The ENGLISH ELECTRIC Group

INTERAVIA

Deadline Notes

No. 7, 1956

NORTH ATLANTIC FARES were the main subject of discussion at the I.A.T.A. Traffic Conference which closed at Cannes on June 25th. The following are the most important innovations decided upon: (1) From October 1st, 1956 airlines are authorized to introduce 15-day "excursion" tickets at the basic rate of $425 return for the New York-London route. (2) From April 1st, 1957 first class services will be divided into two categories: a) a "de luxe" class service costing $450 single from New York to London, with sleeper-type chairs and sleeper cabins (the latter against payment of a special supplement); b) a standard service at $400 single (New York-London), with a greater number of seats, no reclining chairs but with sleeper cabins against extra charge. This arrangement will remain in force until March 31st, 1958. (3) On April 1st, 1958 a completely new "third" class of low fare service will be introduced, with fares 20% below the present tourist rates. The new fares, however, must not fall below $232 single and $418 return between New York and London. Round-trip tickets will be valid for one year. - Commenting on these decisions, Conference Chairman Keith Granville, Sales Director of B.O.A.C., said the settlement amounted to "a revolution in international air transport".

PAN AMERICAN WORLD AIRWAYS recently carried nearly 500 passengers from the United States to Britain on a single day.

SCANDINAVIAN AIR LINES SYSTEM expects to open next January or February a service from Copenhagen to Tokyo via the magnetic North Pole, with a single intermediate landing at Anchorage, Alaska. Aircraft used will be Douglas DC-7Cs.

DEUTSCHE LUFTHANSA now operates a pure freight service twice a week between Hamburg, Hanover, Munich, Stuttgart and Düsseldorf.

CONTRAVES A.G. has inaugurated new production plant and offices at Zurich-Seebach. The company, a member of the Oerlikon Machine Tool Works, Bührle & Co. group, supplies electronic fire control equipment to the Swiss Air Force and Anti-Aircraft Units, has a branch in Sweden and makes substantial deliveries to N.A.T.O. countries through Contraves Italiana. Anti-aircraft units in Norway, Holland, Belgium, Germany, Spain, Italy, Yugoslavia and Brazil work with Contraves Italiana equipment. The company also manufactures analogue computers, control systems, precision gears, etc. - During the inauguration ceremony Board Chairman E.G. Bührle gave an outline of the twenty-year history of Contraves, which now employs roughly 700 engineers, workers and office staff in Zurich, in addition to the staff of Contraves Italiana and the Swedish branch.

FOKKER, Amsterdam, made a net profit of 363,437 guilders in 1955, after depreciation and transfer to the reserve fund, compared with 298,951 guilders in 1954. One of the main items on the production programme is the construction of 460 Hawker Hunter jet fighters. A total of twenty S.14 jet trainers was delivered to the Netherlands Air Force up to April 1956. The biggest research and development order came from the Nederlandse Instituut voor Vliegtuigontwikkeling (Netherlands Institute for Aircraft Development) and concerned the designing and construction of four Fokker F.27 Friendship turboprop prototypes. Sales prospects for this aircraft are considered to be good. It is believed that further investments will be necessary in connection with an expected increase in Friendship production.

A LICENCE AGREEMENT has been signed between the French aircraft manufacturing firm of S.N.C.A. du Nord and the German firm of Flugzeugbau Nord GmbH. The German company will build 117 twin-engine Nord 2501 Noratlas transports, while the French firm will supply twenty Noratlas direct to the German Air Force. All aircraft will be fitted with SNECMA engines (Bristol Hercules licence).

ETABLISSEMENTS FOUGA have obtained a licence for production of the German Dornier Do 27 communications aircraft, and the German firms of Messerschmitt and Heinkel are to build the Fouga Magister jet trainer under licence.

GENERALE AERONAUTIQUE MARCEL DASSAULT has received an order from the Indian Government for 110 Mystère IVA jet fighters with Hispano Suiza engines.

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

GOLDEN ARROW will be the name of the Convair 600 Skylark medium-range jet transports in airline service. The exterior of the aircraft will be of a golden colour instead of the conventional silver. Thirty Skylarks have already been ordered by T.W.A., and another ten by Delta Air Lines. Total value of the two orders, including engines and spares, runs to more than $200,000,000. First deliveries end of 1959.

THE CONVAIR DIVISION of General Dynamics Corp. has received from the U.S. Air Force an order to the value of $61,528,000 for an undisclosed number of F-102s. The order will necessitate the employment of 4,000 additional workers during the next twelve months and will ensure F-102 production well into 1958.

SYSTEMS LABORATORIES CORPORATION is the name of a company founded in Los Angeles with the primary object of engaging in research and development in the field of interplanetary space travel. Initial capital $1,250,000. In the opinion of company President Dr. John L. Barnes, Professor at the University of California, manned rockets should be able to penetrate interplanetary space within the next fifteen years. His programme covers three stages: (1) non-stop flight to the moon and back by an experimental vehicle carrying instruments only; (2) flight round the moon by a vehicle carrying animals; (3) flight to the moon and back by a vehicle carrying two human observers.

NEPTUNE PRODUCTION PLANS: The Japanese Government has formally opened negotiations with U.S. authorities to decide on production plans for the Lockheed P2V-7 Neptune patrol aircraft in Japan. According to preliminary reports, Japan is to produce some 60 Neptunes by the end of fiscal year 1960.

THE JAPANESE GOVERNMENT on June 19th approved three technical contracts signed recently between Japanese and American firms. One of the three provides for the supply of technical data by International General Electric Co. to Ishikawajima Heavy Industries, which will enable the Japanese concern to manufacture the General Electric J-47 jet engine. The contract is valid until May 12th, 1965.

THE UNITED STATES AND BRITAIN signed two agreements on June 25th extending the long-range proving ground for guided missiles in the Caribbean and the South Atlantic from 1,000 to 5,000 miles. The range now stretches from Florida to Ascension Island in the South Atlantic mid-way between South America and Africa. It previously ran from Cape Canaveral in Florida through the Bahamas to Puerto Rico, and there were tracking stations on the islands of Grand Bahama, Eleuthera, San Salvador, Mayaguana, Grand Turk, in the Dominican Republic and Puerto Rico. This area is now extended through the British territories of St. Lucia in the Windward Islands to Ascension Island in the South Atlantic.

*

WORKSHOP BRIEFS . . .

Three delta-wing fighters were shown for the first time at the Tushino, Moscow air display. All are attributed to designer Sukhoy. Characteristic features of one of the three are described as follows: long cylindrical fuselage of constant section from the air intake in the nose to the tail attachment; annular air intake round a supersonic diffusor off-centred towards the top; delta wing with approx. 60° leading edge sweep; sharply swept elevator and rudder units. * The North American F-107 fighter powered by a Pratt & Whitney J-75 turbojet is scheduled to begin flight tests this month. * Four Vickers Viscount 810s have been ordered by Compania Cubana de Aviacion; delivery end of 1958. Three Viscount 700Ds have already been supplied to the Cuban airline. * Two new versions of British jets have been announced: Bristol Olympus BOl.12 and Rolls-Royce Conway RCo.8. - Rolls-Royce confirms that the Dart RDa.8 turboprop has air-cooled turbine blades; shaft power: 2,300 s.h.p. * Société Bronzavia has obtained from D. Napier & Son Ltd. exclusive manufacturing rights for Spraymat de-icers in France and the French Union. * The Chance Vought F8U-1 Crusader supersonic carrier-based fighter is fitted with a variable-incidence wing. * Six more Hurel-Dubois HD.321s are to be ordered by the French Institut Géographique National. The first of the previous order will be delivered in February 1957. * Two new versions of the Gloster Meteor, designated U.15 and U.16, are announced. Both are standard versions of the twin-jet fighter converted for use as remote-controlled guided missile target aircraft. * Hawker Sea Hawk FB.3 and Sea Hawk FGA.4 carrier-based jet combat aircraft are being fitted with more powerful Rolls-Royce Nene RN.6 (Nene 103) engines of 5,400 lbs. static thrust. With this engine the aircraft will be known as the FB.5 and FGA.6 respectively.

* * *

Safe Airways

The writer first became acquainted with the notion of "air traffic control" in the mid-twenties, when he climbed aboard what was then called a commercial aircraft for an hour's flight between two neighbouring cities. As the "cabin" was already fully occupied by six passengers, he was installed—in the open—next to the pilot, pulled his hat well over his eyes and his coat tight around him. There seemed to be a slight difficulty in taking off from the dewy meadow. At any rate the pilot called to the starter, armed with a small flag, and pointing to an agricultural vehicle parked 200 yards away, shouted: "Can't you move that dung cart. I won't be able to get this thing off the ground!" A horse was fetched, harnessed up, and the requirements of "flight safety" were met.

In that year the airlines carried 50,000 passengers whereas in 1956 the total is expected to reach more than a hundred million. And air safety, which aroused little attention from the statisticians in those days, increased fivefold in the decade between 1945 and 1955, I.C.A.O. reports. In other words, in 1945 there were 3.01 fatalities per 100 million passenger-kilometres performed, but in 1955 only 0.66.

Thus world air transport has now reached a high degree of safety. Nevertheless, since mid-1955 there has been more talk than ever of air safety and air traffic control. Take, for example, all that has been discussed, proposed and decided in recent weeks at I.A.T.A.'s Technical Conference in Cannes and I.C.A.O.'s General Assembly at Caracas. Why is it that so much discussion in the aviation organizations centres round this subject?

The airlines are just about to introduce jet aircraft, whose high speeds make them doubly demanding on ground facilities, and which must be able to take off, fly and land in any weather conditions. For both economy and safety reasons, pure jet or turboprop aircraft cannot be expected to stack endlessly before landing or to continue to alternate airports.

This is the main reason why the experts in general and the writers in this issue in particular are not satisfied with what has hitherto been achieved. In view of the expected intensification in traffic and of the increase in speeds, they are loudly demanding the provision of adequate technical and financial resources to adapt ground organization and airborne equipment to the tasks ahead.

It is therefore no surprise that serious criticism is voiced in some of the contributions to the present issue. For example, a study group of prominent American experts (see the Barclay Harding Report) shows unequivocally that present U.S. appropriations for the ground organization are by no means adequate. *Interavia's* Study Group analyses the accident statistics and calls for increased attention to the human factor in flight operations. The same trend is also followed by Chief Pilot Lecarme, of S.N.C.A. du Sud-Est, who presents certain basic truths on airborne instruments.

However, the writers do not restrict themselves simply to pointing out deficiencies and lags in development, but apply the same objectivity to the impressive advances that have been made in all branches of traffic safety in recent years and make constructive suggestions for the immediate and more distant future. Lockheed Chief Engineer Haddon takes the *Electra* as an example to illustrate the many ways in which the aircraft designer can improve air safety. P. Oomen, an I.C.A.O. technical officer, discusses new methods of improving communications and air traffic control. W. Stanner reviews present and projected radio navigation systems. And a report on the U.S. Civil Aeronautics Administration's five-year plan reveals that nearly $ 250,000,000 is to be spent on navigation aids and radar installations. — In a lighter vein, the American cartoonist Robert Osborn suggests the monstrous kind of prototype that can result when the designer is stormed from all sides with conflicting requests and demands.

From chipping come chips. The reader will frequently come upon the words "accident", "incident", "human error" in the following pages. Such an accumulation of "unpleasantnesses" is, however, by no means characteristic of normal flying operation, but merely serves to illustrate the tireless efforts being made by all—pilots, designers, airport officials, meteorologists, radio operators, transport experts—who are responsible for maintaining and improving the high degree of safety already reached in world air transport.

The traveller need therefore have no hesitation in going by air. Or should we, for safety reasons, return to the stage coach?... In 1606 the coach carrying King Henry IV of France and his Queen slipped off the ferry at Neuilly into the Seine. When no longer a young man, Goethe and his companion, art professor Meyer, were tipped into the ditch two hours after leaving Weimar. And in 1842 the young Duke of Orleans, son of King Louis Philippe, broke his neck while trying to jump from his carriage after his horses had bolted.

Interim

Long-range radar station at Idlewild Traffic Control Center, New York.

Commercial Aviation Safety Increases Twentyfold in Twenty Years

BY INTERAVIA STUDY GROUP

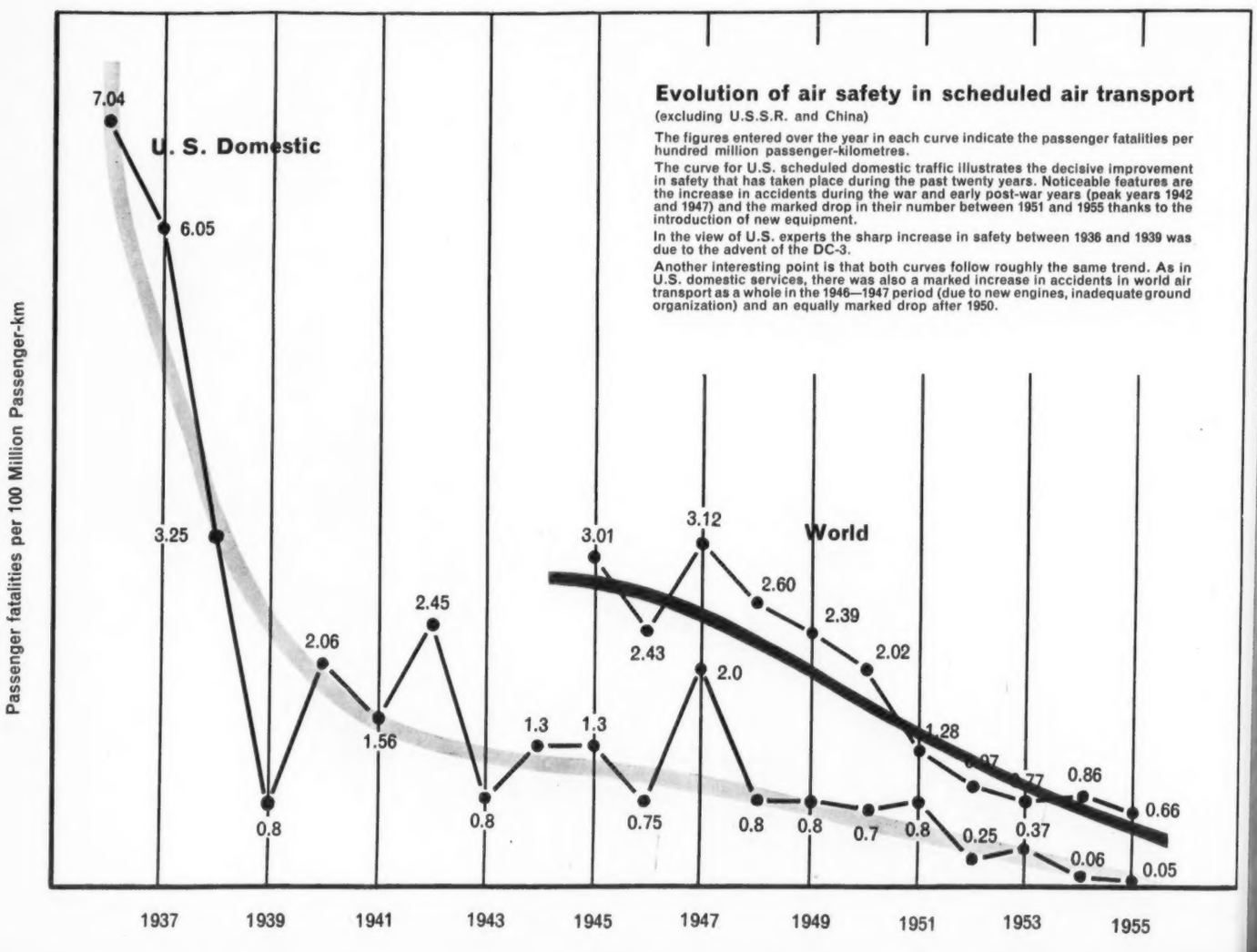
During 1955 the world's airlines[1] carried a rough total of 70 million passengers. For every hundred million passenger-miles produced by the fleets of the airlines operating regular services the fatality rate was 0.66. This means that if the population of a town of 150,000 inhabitants were moved over a distance of 1,000 miles, the whole mass movement could be effected at the cost of a single human life. During the past twenty years speeds of commercial aircraft have multiplied three-fold and weights and ranges five-fold. In the same period the risk of accidents has been reduced 10 to 15 times for the world network as a whole.

[1] Excluding the Soviet Union and China.

Despite heated controversy, tremendous progress has been made through the efforts of countless experts. Mathematicians, physicists, chemists on the one hand, and aerodynamicists, engine and accessory designers, operators, pilots, traffic controllers etc. on the other, have contributed directly or indirectly to reversing the trend towards lower aerial safety noted early after World War II and to bringing the safety of air travel into closer relationship with that of the means of surface transport. In his 1951 report on "Human Factors in Air Transportation", Ross MacFarlane produced the following comparative figures for safety in air transport and surface travel (number of passenger killed per 100,000,000 passenger-miles performed).

Air Transport (U.S.A.)		Rail	Bus	Car
domestic	intern.			
0.8	0.76	0.25	0.138	1.5

During the black year of 1947 there were no fewer than 80 deaths in four months in the United States alone. Since then other countries in turn have faced and overcome similar crises. As late as December 1953 the violonist Yehudi Menuhin refused to travel to Israel by air and cancelled a concert he was to have given in Tel Aviv. He explained that after the tragic deaths of Thibaud, Kapell and Ginette Neveu he had decided to give up air travel until instrument


Evolution of air safety in scheduled air transport
(excluding U.S.S.R. and China)
The figures entered over the year in each curve indicate the passenger fatalities per hundred million passenger-kilometres.
The curve for U.S. scheduled domestic traffic illustrates the decisive improvement in safety that has taken place during the past twenty years. Noticeable features are the increase in accidents during the war and early post-war years (peak years 1942 and 1947) and the marked drop in their number between 1951 and 1955 thanks to the introduction of new equipment.
In the view of U.S. experts the sharp increase in safety between 1936 and 1939 was due to the advent of the DC-3.
Another interesting point is that both curves follow roughly the same trend. As in U.S. domestic services, there was also a marked increase in accidents in world air transport as a whole in the 1946—1947 period (due to new engines, inadequate ground organization) and an equally marked drop after 1950.
U. S. Domestic
World
Passenger fatalities per 100 Million Passenger-km
7.04
6.05
3.25
0.8
2.06
1.56
2.45
0.8
1.3
1.3
0.75
3.01
2.43
3.12
2.60
2.39
2.02
2.0
0.8
0.8
0.7
0.8
1.28
0.25
0.37
0.06
0.86
0.66
0.05
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955

The I.A.T.A. conference at San Remo advocated the general introduction of airborne radar. — The radar nose of a Convair-Liner, whose storm-warning radar can detect bad weather zones up to 150 miles away.

The control room of C.A.A.'s Air Traffic Center at Idlewild, New York during a peak traffic period in bad weather. The Center controls 30 terminal airports, 12 military air bases and innumerable private airfields. It is responsible for flight control on 3,400 miles of low frequency and 4,200 miles of high frequency airways. — *Top to bottom:* the head of the Air Traffic Center checks the latest fix postings of aircraft flying into the control area (often several hundred); a doubtful fix posting being checked on one of the 13 PPI scopes forming part of the vast radar system (General Electric FPS-8); an air traffic controller at work.

flying had become safer. His decision was not motivated by fear, he added, but was intended to encourage the introduction of constructive measures to prevent the type of accident that had claimed friends of his on three separate occasions. Even the simplest form of radar should be capable of detecting a mountain in the aircraft's path, and he considered it was not too much to expect all aircraft to be properly equipped in this respect. Since that date radar has in fact been fitted in many commercial aircraft, though one installation recommended by C.A.A. not so long ago was found to be too inaccurate to contribute much to the solution of the problem. However, much progress has now been made by the electronic experts, and Yehudi Menuhin's wish is no longer so far from fulfilment.

Air forces too have been able gradually to reduce the risks run by their personnel during training. The U.S. Air Force progressed from 24 accidents per 100,000 hours flown in 1946 to 12 four years later.

Only private flying in all countries still has a high accident rate. Though the number of accidents to private aircraft (touring aircraft, air taxis, etc.) in the United States continually decreased between 1947 and 1950, this was because the amount of flying by these aircraft was similarly reduced. The percentage of accidents in relation to the number of hours flown has remained roughly constant. Out of the 4,477 accidents recorded in 1950, 3,511 fell into the wide category of accidents due to pilot error. Structural or mechanical failures were found to be the cause in only 316 cases, or 7% of the total. Since the human factor looms so large and it is so difficult to check the qualifications of private pilots sufficiently closely, it is obvious that the accident rate in light flying cannot properly be compared with those for commercial or military flying.

Peacetime difficulties

During the war the U.S. and British Air Transport Commands not only supplied world-wide fronts but also created needs and markets and established a vast ground organization operated by hundreds of thousands of servicemen. The end of the war, followed by rapid demobilization, suddenly deprived renascent commercial aviation of its support. Moreover, the war had divided the world into two. While on the one side it had enabled U.S. air transport to grow to giant proportions and had speeded up the development of new techniques and new procedures, the peoples of continental Europe had been obliged to mark time. The Paris conference organized by P.I.C.A.O. in May 1946 revealed the gap separating old and new worlds. American delegates, already accustomed to ILS and GCA, were amazed to hear their European colleagues still vaunting the merits of pre-war approach systems. The new airlines were suffering from an overdose of badly digested technical progress, swallowed hastily in an effort to establish themselves in the world market without delay.

In 1947 there were 240 passenger fatalities in the United States, 212 in France and more than 300 elsewhere in the world. Between August 1946 and the end of February 1947 there were 44 serious accidents involving 794 deaths.

Two years ago Chan Gurney, at that time Chairman of the U.S. Civil Aeronautics Board, proposed the creation of an inter-airline and ultimately international air safety organization. Though the idea was attractive, it was dropped, principally on account of the complexity of the problem. Every airline on the one hand and

every country on the other has its own methods, its own rules and even its own concepts when it comes to assessing a given accident. Despite ten years of discussion around the conference tables and hundreds of inquiries, agreement is far from having been reached on all the causes and all the remedies. The engineers blame human error, aircrews the equipment, and the operator the combination of both. An air accident results as a rule from a chance accumulation of circumstances which taken together lead to catastrophe. Nobody agrees on the relative importance of each event or on what aircrews and ground personnel could do to improve matters.

One of the most valuable treatises on air safety, devoted solely to the U.S. scheduled services, was written by W. K. Andrews of the C.A.B.'s Bureau of Safety Investigation. The scope of American air transport is sufficiently broad to provide the statistician with large figures to work on, though the conclusions drawn cannot necessarily be adapted directly to conditions elsewhere. Instead of sticking to the conventional method of expressing accident figures in relation to passenger-miles performed, Andrews gives the number of fatalities in relation to the number of hours flown. To obtain a sufficiently broad basis for his investigation he extends it to all scheduled flights between 1951 and 1953 by aircraft with a gross weight of more than 13,000 lbs. The tables below summarize the first results of the inquiry.

No. of hours flown during the period	No. of accidents		
	involving fatalities	without fatalities	total
6,972,086	13	89	102

The number of fatalities per 100,000 flying hours was:

— passengers	3.93
— crew	0.65
	4.58

The 102 accidents or serious incidents examined by Mr. Andrews are then classified according to their direct causes. The result, for both fatal accidents and those entailing only injuries or material damage, is as follows:

Direct causes	No. of accidents or incidents	Rate per 100,000 hours
1. Failure or incorrect use of undercarriage	18	0.26
2. Collision with ground, water or ground obstruction	16	0.22
3. Turbulence in flight	13	0.19
4. Overshoot during landing	9	0.13
5. Fire in flight	7	0.10
6. Mid-air collision	5	0.07
7. Failure of airframe in flight	5	0.07
8. Undershoot during landing	5	0.07
9. Collision on ground	4	0.06
10. Failure of airframe on ground	4	0.06
11. Heavy landing	4	0.06
12. Damage due to hail	2	0.03
13. Brusque manœuvre to avoid collision in flight	2	0.03
14. Various incidents due to personnel error	6	0.07
15. Various incidents due to equipment	2	0.02

The Andrews investigation thus reaches the same result as most previous or subsequent inquiries. Collision with a fixed or mobile object during flight accounts for the highest percentage of accidents, with a rate approaching 0.3 per 100,000 flying hours. Weather, ground organization and crews are the three essential elements in the problem of in-flight collisions. Here the experts agree. But disagreement exists

Ben Howard's Proposals for Improving Air Safety

Rejecting the results of all previous investigations, along with all the methods hitherto used for evaluating the causes of air accidents, Ben O. Howard, consultant to the Convair Division of General Dynamics Corporation and to Fairchild Engine & Airplane Corporation, has put forward his own revolutionary theory. "To explain an air accident through an error by the pilot or the crew", he says in substance, "is to sidetrack the real problem. In most cases the pilot only does what can be expected of a specially trained man. The chief error is that too much is asked of him."

A pilot himself and former aircraft designer, Ben Howard rejects the conventional statistics based on hours flown, distance covered or passenger-miles "produced", and analyses instead the number of flights. Examination of a large number of accidents has convinced him that the element of risk is not so much connected with the duration of flight or the miles flown as with take-off and landing, during which, he maintains, 95% of the hazards occur.

On the basis of this reasoning Howard classifies the principal aircraft in service on the U.S. domestic network in order of decreasing safety, as follows: Douglas DC-3, Convair 240 and Douglas DC-4, Douglas DC-6 and Lockheed *Constellation*.

In other words, the obsolescent DC-3, which at full load no longer meets I.C.A.O. standards for rate of climb in the event of failure of one engine, would appear, under this reasoning, to be the safest aircraft, and the more modern the aircraft design the less safe it becomes. Adding additional engines has little effect on safety, since the increased complexity outweighs the other advantages. The theory is all the more surprising since Howard bases his classification solely on take-off behaviour.

Yet Howard is to a certain extent supported by the C.A.B., which listed the accidents and serious incidents occuring to aircraft of various types during a five-year period, placing the DC-3 at the head of its list. The percentage accident rates arrived at were as follows: DC-3 (0.42), DC-6 (0.52), DC-4 (0.54), B-377 (0.6), Convair 240 (0.7), *Constellation* (0.8), C-46 (1.2), Martin 202 (1.4).

I.C.A.O. figures for engine failures recorded during take-off, published several years ago, also confirmed Howard's theory. On the basis of 100,000 take-offs, the DC-3 showed the lowest percentage, with 0.37%, while the four-engined DC-4 had 1.66% and the DC-6 as many as 3.71% engine failures. However, these figures must be treated with care. The results of an engine failure in the DC-3 can be a great deal more serious than in a DC-4 or DC-6, which would still have three-quarters of their power available. Pursued to its logical conclusion, the theory maintains that an aircraft with a single particularly proven engine is safer during take-off than a multi-engined machine.

Ben Howard's theory that take-off and landing are particularly dangerous does not tally with the vast number of other statistics published by civil aviation authorities throughout the world. According to an Anglo-American document, for example, the percentage of accidents occuring during the various phases of flight is as follows:

take-off	11.7%
landing	33%
in flight	55.3%

Out of 33 accidents occurring en route, 24 involved twin-engined aircraft (limited navigation equipment) and only 9 four-engined types. During landing, however, the twin-engined aircraft would seem to be safer than the four-engined, doubtless because of its lower wing loading.

These contradictory figures show how difficult it is to assess the statistics available and even to decide for one theory rather than another.

But Ben Howard's arguments are not limited to the paradoxical. He also points out, not without reason, that despite the efforts of the engineers, the aircraft they produce are still not as safe as they could be. "We are willing to lose considerable sums of money by limiting the payload carried by commercial aircraft," he says in effect, "while fatal accidents occur because the engineers have not yet succeeded in harmonizing the speed at which flaps are retracted with the aircraft's rate of climb in such a way as to retain sufficient lift in the event of an engine failure..." As regards human error—which Howard blames for about 32% of all air accidents—little or nothing has yet been done, he claims, to reduce their frequency. The answer is not to increase the number of safety devices, which merely add to the aircraft's complexity, but to perfect integrated systems which could relieve the pilot of much of his routine work.

The Institute of the Aeronautical Sciences is said to have been somewhat embarrassed when Ben Howard offered to explain his theories to its members. Nevertheless, despite their paradoxical nature, they have, in the form in which the American trade press has published them, rendered the service of drawing the attention of operators and engineers to one vital point: *never demand of a man anything but what he can normally accomplish with a hundred percent chance of success.*

Improved training methods help to increase safety. Swissair aircrews in one of the lecture rooms at the new training centre, Zurich-Kloten. Hours of instruction at Swissair increased from 800 in 1946 to no fewer than 7,800 in 1955.

as to the ultimate responsibility of the crew. In other words, is it possible to avoid all collisions, regardless of weather conditions, with the navigation aids and markings now available, or is it crew error rather than failures in the ground organization that is responsible for the heavy toll paid by air transport through collision with ground or air obstructions?

The degree of safety obtained over the oceans might suggest that the weakness lies with man rather than with equipment and ground organization. As early as 1950, C.A.B. noted that during the preceding twelve years P.A.A., A.O.A. and T.W.A. had made 61,000 crossings of the Atlantic with a total of seven accidents (two of which occurred during the war) and 97 fatalities, while during the same period the 16 domestic scheduled airlines experienced 54 accidents claiming 910 deaths. The reason is that errors of navigation over the ocean can be made good without leading to collision with the ground. Between 1950 and 1954 the airlines operating regular trans-Atlantic services carried some 2,130,000 passengers in the two directions. With the exception of the points of departure and arrival (accidents at Shannon, Newfoundland, Prestwick) and intermediate landing (accident in the Azores), the purely over-water stages have been remarkably safe.

Hence human error would appear to be the main reason for the lack of safety in the air. The Canadian aviation authorities estimated that of the 279 accidents or serious incidents recorded during 1947, 51% were due to pilot error and only 14.3% to material failure. In 1949, U.S. Air Force and Navy agreed that 70% of their air accidents must be attributed to crew error, and four years later, testifying before Congress, U.S.A.F. chiefs stated that there was an average of 29 accidents per 100,000 hours flown by the air forces and that 51.3% of these accidents were due to errors of judgment, 27.4% to equipment defects, 6.5% to faulty maintenance, and finally 14.8% to various causes, including in particular weather conditions.

In Italy, Salvatore Tomasino studied the figures for the I.A.T.A. member companies and reached the following relative percentages:

Causes	Periods considered	
	1936—1940	1944—1946
Crew error	42.4%	58.5%
Equipment failure	29.3%	19.5%
Other	28.3%	22%

The Italian expert showed not only the part played by human error but also that the latter increased with the weight and general complexity of aircraft, and with the fact that operating conditions were much less restricted, especially as regards weather. Pilot errors were not numerous and may well be due to the size of the task.

Figures produced by C.A.B.'s safety investigations also clearly show the part played by human error.

Year	Total No. of accidents	No. due to pilot error	Percentage
1947—1951	583	260	44.5%
1951	118	50	42.5%
1952	105	40	38%
1953	94	37	39.4%

In all airfaring countries a study of accident inquiries and a close examination of operating statistics lead to roughly the same results: human error accounts for 40 to 50% of air transport accidents and an even higher percentage of military accidents.

Is it possible to improve man so that he may gradually become equal to the tremendous task demanded of him, or must and can the engineer lighten this task by perfecting new methods of navigation and flight control? It would seem that only a combination of both efforts—on man and on his equipment—can lead to greater air safety.

In a paper read to the Royal Society of Arts, Air Commodore Sir Vernon Brown, former Chief Inspector of Accidents at the Air Ministry and later the Ministry of Civil Aviation, stressed the problems raised by pilot fatigue, the effect of noise, vibrations and even domestic worries on the members of the crew and discussed in detail what he so correctly called the psychological causes of air accidents. In the United States, Dr. Walsh, of the Mayo Clinic, demanded a physio-psychiatric examination for all commercial pilots, with annual or semi-annual checks. In Australia, T.A.A.'s 300 pilots are subjected to constant medical and even "social" supervision to ensure that crew members are in perfect physical and psychological condition.

The recent report by C. R. Spealman of C.A.A.'s Medical Division, should contribute greatly to reducing the number of accidents due to human error. Using the accident statistics available to C.A.B. (for a period covering 1948 to 1951) and the reports on accident inquiries, he examined the direct and indirect causes of nearly 500 accidents and selected those that were undeniably due to pilot error. He noted the errors committed, either consciously or unwittingly, under normal conditions, and the human errors committed under abnormal conditions such as equipment failure or exceptionally bad weather. Finally he listed a certain number of accidents caused by ill-defined errors

Careful maintenance of equipment is a cornerstone of air safety. Air France mechanics working on a *Constellation's* engines.

Through the use of flight simulators commercial pilots and flight engineers can be acquainted with all the qualities of the aircraft they are to fly long before taking off on the first training flight. *Left:* AT-100 type trainer (Air Trainers Ltd.) used by the Canadian Department of Transport for the training of crews for the Vickers *Viscount 724* turboprop aircraft; *right:* the instrument panel.

or involving personnel other than the aircrews.

Out of the 109 pilot errors considered, 103 led to accidents and 33 to fatal accidents (32%). Under normal flying conditions pilots made 22 conscious errors leading to 56% of the fatal accidents and 2 involuntary errors causing 9% of the fatalities. Under exceptional conditions pilots made 22 errors, 5 of which entailed fatal accidents. Finally, 21 pilot errors involving 5 fatal accidents were impossible to classify because of the overlapping of responsibilities concerned.

The C.A.A. report shows that conscious errors—that is, for example, failure to observe rules—committed under normal conditions accounted for the largest number of air disasters. Improved training and discipline and, above all, constant checks, should enable the frequency of such errors to be reduced. The errors made by pilots faced by exceptionally difficult circumstances number only about half as many as the former category. Though it is impossible to eliminate emotional factors and difficult even to limit their effects, it should be possible to find technical aids to reduce the number of accidents resulting. In addition, a stricter physical and psychological selection during recruitment would eliminate candidates liable to lose their nerve.

Man let down by his equipment

With slight variations, all these investigations place man—in this case the pilot—in the dock. According to them, the aircraft is no longer to blame, weather conditions are of secondary importance and ground organization is adequate. Major blame is laid on the weakneses of the man at the controls. It is therefore interesting to recall the lecture read to the Institute of the Aeronautical Sciences by W. Moss of the Air Line Pilots Association of America. The speaker admitted that 40 to 50% of air accidents must be booked against the pilot, but argued that in the majority of cases the pilot was not responsible alone and thus opposed at least part of Spealman's reasoning. After examining the figures for the United States domestic network during the period 1938–50, Moss drew the following interesting conclusions:

—The degree of safety of an aircraft depends on its design. Otherwise the crew has trouble in meeting any difficulties that arise. It is up to the designer to plan his machine for maximum safety.

—The first few years of operation are insufficient to get rid of all the "bugs" in a new aircraft type. Constant vigilance is required and a safe aircraft is the result of "continuous creation".

—The growing complexity of instrument panels constitutes a real danger.

Moss considered that if certain critical controls were organized in such a way that two consecutive false moves were needed to get the aircraft into difficulties, 7 to 8% of the accidents attributed to pilot error could be avoided. He also recommended the general use of reversible pitch propellers. (Andrews' report blamed overshooting during landing for 9 accidents, representing a rate of 0.13 per 100,000 flying hours.) Similarly, if radar were fitted in all commercial transports, 6.5% of pilot errors could be eliminated. In all, A.L.P.A.'s representative thought that purely technical improvements could prevent 40% of present pilot errors and reduce the number of accidents by 25%.

The battle for safety

It cannot be denied that much progress has been made by aircraft manufacturing and air transport industry during the past ten years on the road to increased safety. Examples are backward facing seats and the reduction of fire hazards by the suspension of engines beneath the wings and the provision of automatic cut-off for fuel lines. The last I.A.T.A. Conference at San Remo, for instance, unanimously approved P.A.A.'s proposal for general introduction of airborne radar, so that all commercial transports now being built will doubtless be equipped in this way.

There remains the human element to improve, a subject to which doctors and psychologists have turned their attention. The example of Trans Australia Airlines shows that an answer can be found to the problem of human error. Much still remains to be done, however, in both the human and the technical field to ensure that the annual accident rate should drop as quickly as possible. Under normal circumstances the world rate should be in the region of 0.4 or 0.5 per 100,000,000 passenger-miles by about 1960, so that flying will be 20 to 25 times safer than it was twenty years earlier. What other branch of transport can boast so much progress in so short a time?

Warning on U. S. Aviation Facilities

The Barclay Harding Report[1]

In the years before 1926—when aviation in the United States was in its infancy—there was no question of "air traffic control problems". In those days the Bureau of Lighthouses was able to handle all questions pertaining to air control, navigation aids and communications. Today, three decades later, the overcrowding of America's airways and airports has taken on alarming proportions. At the end of 1955 there were roughly 90,000 civil and military aircraft active in the United States . . . not to mention the other "users" of the air space, such as guided missiles, as well as wireless communications, radio, television etc.

Of course, it is not only the Americans who have their worries about *allocating space in the air and on the ground.* As the discussions of the Tenth I.C.A.O. Assembly in Caracas[2] and I.A.T.A.'s Ninth Technical Conference at Cannes show, all the airfaring countries are actively seeking solutions to these complex problems, solutions which have become even more urgently needed since, with the Boeing 707 and Douglas DC-8 going into production, air transport has definitely crossed the threshold into the jet age. The fact that both these long-range aircraft are of American design explains the United States' particular interest in questions of airway and air traffic control. How serious the situation really is can be seen from the Air Transport Association of America's statement that there are "*four reported near collisions involving the airlines daily*" . . . and this several years before the opening of the jet services.

It is therefore not surprising that the U.S. authorities should regard coming developments with growing anxiety. In order to get an overall picture of the present organization and future requirements for aviation facilities and navigation aids, the Director of the Bureau of the Budget set up a study group in the summer of 1955 to work out forecasts for a period of about twenty years.

The study group was headed by Barclay Harding, Colonel in the U.S. Air Force Reserve and partner in the banking house of Smith, Barney and Company, New York, which has been concerned for the past twenty years with investments in the aircraft manufacturing and air transport industries and airport management companies. Other members of the group were well-known experts from various fields of aviation[3]. At the end of 1955, after consulting aviation authorities, airlines and aircraft industry, the group submitted a report entitled "Aviation Facilities" containing a number of basic recommendations that merit examination outside as well as inside the United States. The committee's most important findings are given in brief below, headed by the four assumptions upon which the report is based:

(a) Speeds of commercial transports can be expected to increase from the present average 300 m.p.h. to 1,000 m.p.h. within the next twenty years;

(b) Jet airliners will be operating at altitudes which are today the preserve of service aviation (40,000 feet and above);

(c) The productivity of commercial transports (payload multiplied by the number of miles operable within a given period) will improve considerably. Even the jet transports due for service in 1959–60 will be able to produce three times the annual transport volume of present aircraft, and the productivity of future atomic-powered aircraft cannot even be forecast;

(d) Operating costs should fall by about 30% per seat-mile in passenger operations and by 80% per ton-mile in freight services. Helicopter operating costs, now ten to fifteen times as high as those of fixed-wing aircraft, should drop to about three times those of fixed-wing aircraft by the late 1960's. No estimate can yet be made for other vertical rising or steep gradient aircraft.

All this indicates that there will be a powerful increase in flying. The individual contributions to the report then examine how far U.S. aviation facilities are equal to their coming task.

Aircraft "milling around"

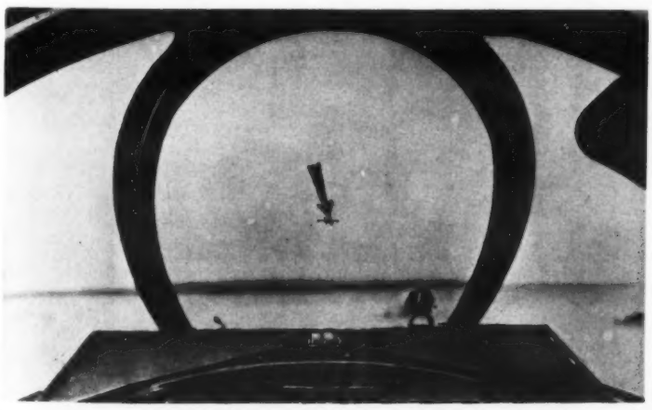
The section on "Operating Problems" is written by Harold R. Harris, a Brigadier General in the U.S. Air Force during the war, a top executive of Panagra for 14 years before the war and later successively Vice President and General

[1] *"Aviation Facilities":* The Report of the Aviation Facilities Study Group to the Director, Bureau of the Budget, December 31st, 1955.

[2] *Interavia* No. 6, 1956, p. 451.

[3] *George P. Baker,* President of the Transportation Association of America; *J. Gordon Bennett, Jr.,* Assistant to the Under Secretary for Transportation; *Fred M. Glass,* Senior Vice President and Executive Officer, Empire State Building Corporation; *N. E. Halaby,* attorney; *Harold R. Harris,* President of Aviation Financial Services; *Jerome Lederer,* Director of the Flight Safety Foundation; *T. F. Walkowicz,* aviation adviser to Rockefeller Institute.

Good visibility is not always enough in high-speed aircraft to prevent collisions. Here the speck on the horizon marked by an arrow – and almost imperceptible by the pilot – is a Northrop F-89 jet fighter.



As both aircraft are approaching each other head-on, their combined speed of approach is about 1,000 m.p.h., so that *four seconds later* the F-89 is dangerously close.

Air Safety

Manager of American Overseas Airways, Vice President in charge of Pan American World Airways' Atlantic Division and President and Chief Executive of Northwest Airlines.

The study group believes that the number of active military aircraft will increase only slightly between 1960 and 1965 and then probably decline as guided missiles take over more and more duties. On the other hand the number of active civil aircraft is expected to grow by about 30% in the next twenty years. The question of how close the United States is to a safe, efficient aviation facilities system is answered with considerable scepticism. Answers obtained from circles closely connected with the problem indicate that the desired objective is still far from having been met.

With the present overloaded traffic control system the number of aircraft in the air during bad weather has to be arbitrarily limited in an effort to prevent collisions on the airways. The resulting delays impose a heavy economic burden on civil aviation and restrictions on military aviation that might well be unacceptable in times of national emergency.

The present rules for instrument flying in the United States are recapitulated here to illustrate the situation. When the weather en route is such that the pilot cannot navigate from ground landmarks, and horizontal visibility falls below 3 miles, he must file an instrument flight plan, i.e., fly under Instrument Flight Rules. The flight is then constantly checked, as regards route and altitude, by C.A.A. air traffic controllers, and the aircraft is surrounded with a "cocoon" of reserved air space about 100 miles long, 2,000 feet thick and 10 miles wide.

Radar screens at Washington National Airport. Left, airport surveillance radar; right, landing approach radar *(C.A.A. photo)*.

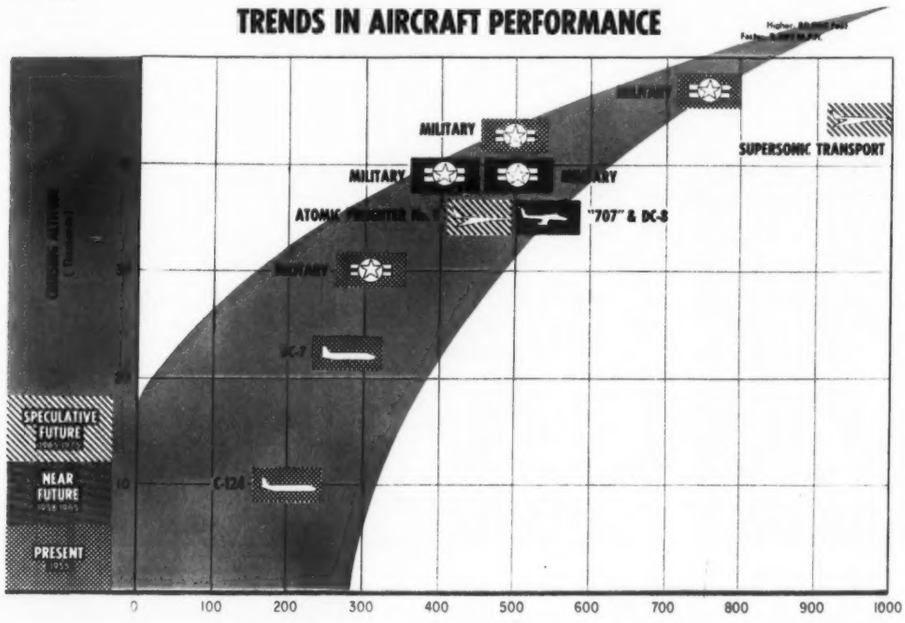
Under Visual Flight Rules pilots can fly in any direction they wish without telling anyone of their plans.

It is quite possible for VFR and IFR flights to take place simultaneously in the same area. In other words, commercial transports, sports aircraft and jet fighters may be "milling around" in the air space with their pilots relying on their eyesight and luck to avoid collisions. The pilot of a high-speed aircraft, however, cannot keep a permanent look-out for other aircraft, since he must constantly watch his instruments. Time and motion studies have shown that it takes a pilot about seven seconds to change direction after seeing an obstruction. But in seven seconds a modern jet fighter flying at 650 m.p.h. will have covered a distance of well over a mile.

The group comes to the conclusion that the United States are "continuing to fly more aircraft faster, higher and more and more often." Several responsible quarters have described the situation as "*flagrantly defying the law of averages*".

The report then asks whether all aircraft should not be subjected to air traffic control in all weather, good or bad. This is easier said than done, as appears from the next section in the report.

Present and future speeds (miles per hour, entered in the horizontal) and cruising altitudes (in thousands of feet, vertical) of selected U.S. civil and military aircraft categories. Those in operation today are indicated by cross-hatching; the types scheduled for the near future by close-set hatching, and the categories not yet under construction by spaced hatching.



C.A.A.'s navigation and traffic control aids

"Air Navigation and Traffic Control" is the title of the section contributed by T. F. Walkowicz, who since completing his studies (Massachusetts Institute of Technology and California Institute of Technology) has served in various capacities with the defence authorities. Appointments have included Staff Officer at the Air University, Maxwell Field, Alabama, and Executive Secretary to the U.S. Air Force's Scientific Advisory Board.

In mid-1948 the Radio Technical Commission for Aeronautics reported that "the tools available to C.A.A. for discharging this task (of regulating air traffic) are marginal even by prewar standards . . . At present, the only position information available to controllers . . . may be in error by many miles . . . For safety reasons, passengers expecting to arrive at Washington at 6.30 p.m. may well land at Philadelphia at 11.45 p.m. . . ."

Apparently little improvement has been made during the past eight years, for the report adds "This 1948 quotation still describes the situation in 1955."

Reasons for the lack of progress are simple. Total flying hours in the United States have more than doubled since 1948, while only $110,000,000 have been spent on the C.A.A.'s traffic control programme. Though appropriations of $670,000,000 have been granted for the Semi Automatic Ground Environment (S.A.G.E.) radar network, which has been under development since 1949, under present rulings this system is to be used only for air defence purposes.

It is therefore recommended that (1) the military radar network and the civil traffic control system be coordinated; (2) the growth of helicopter traffic be allowed for in planning traffic control development; (3) U.S. and Allied control systems be integrated.

Airports also inadequate

Criticism of the U.S. airport organization is provided by Fred M. Glass, who from 1949 until recently was Aviation Director of the Port of New York Authority and hence in charge of four of the country's most important airports—Idlewild, Newark, La Guardia and Teterboro. He is now Senior Vice President and Chief Executive Officer of the Empire State Building Corporation.

There are today 700 major civil and military airports in use in the United States and over 6,000 civil airports of lesser importance. Whereas more than $3,000,000,000 has been spent on military airfields since 1951, Federal appropriations for civil airports have remained at $116,000,000 (excluding special appropriations such as those for Washington's National Airport). Among airport improvements required

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are longer and stronger runways, clear approach zones, high intensity lighting, larger passenger and cargo handling areas, etc. The report concludes that responsibility for financing, managing and planning civil airports should remain at the local level, as hitherto, but that the Federal Government must accept responsibility for overall planning of a national airport system and for providing such funds as are needed in the national interest.

Local airport managements have complained, it is reported, that they have not been adequately informed of the traffic requirements they are expected to meet. Here a radical reorganization is needed to prevent the airports from becoming a "bottleneck" in U.S. aviation. The urgency of this question becomes apparent when it is realized that there is at present not a single civil airport in the United States capable of handling the Air Force's long-range bombers at full operational loads in time of emergency.

Conclusions and recommendations

As a result of its investigation the study group makes the following recommendations:

(1) There should be much greater coordination of the activities of the various departments and agencies responsible for the development and operation of aviation facilities. Under present conditions there is a risk of a dangerous situation developing.

(2) To avoid overlapping and the wasteful expenditure of labour and funds, it would be desirable that all studies concerned with a national aviation facilities programme be directed by a *single* individual of high standing serving under a temporary appointment in the President's Executive Office. There are at present over 75 different committees, subcommittees and working groups handling aviation facilities questions, so that coordination has become an increasingly difficult problem.

Air/Ground Communications

BY P. OOMEN

Technical officer, International Civil Aviation Organization, Montreal

The Problem

It is not necessary here to emphasize the growing concern of the aviation industry that, with the facilities available at present for such services as air traffic control, operational control, meteorology etc., it is increasingly difficult to satisfy the operational requirements for a safe and efficient flow of air traffic; nearly every issue of the more influential aviation periodicals refers to this problem in one way or another. Apart from the problems inherent in the internal structure of these services, their efficient functioning depends upon the availability and quality of the associated communication channels, both point-to-point and air-to-ground. A chain is as strong as its weakest link, and if the weakest link in the case of air navigation facilities would happen to be the communication channels, no amount of improvement in, say, the organization of air traffic control services could be expected to show any marked beneficial effect. In this article, we will concentrate on the problems of the air/ground communications only and review their adequacy to satisfy present and future requirements, indicating some of the possibilities for improvement and the development of new techniques.

Present Air/Ground Communications

The present system of communications between aircraft and the ground is essentially a radiotelephony system. For medium and long range communications radiotelegraphy still can be used in many areas of the world, but there is a continual trend to replace this method by telephony. In fact, ICAO regional plans for the international aeronautical mobile services (Air/Ground Services) recommend that radiotelephony should be the "primary means of communications".

For short distance communication increasing use is made of very high frequencies (VHF) which offer the advantage of static-free reception but have a range limited to approximately line-of-sight distance. Medium and long distance communications are conducted on high frequencies (HF), of which the range varies between zero and thousands of kilometers, depending on the frequency used, the time of day, and several other factors. Long distance, HF communication may suffer severely from static, distortion, and, on high latitude routes, communication can be completely interrupted during ionospheric disturbances and radio fade-outs, sometimes lasting only a few minutes, at other times for several days.

Shortcomings of the present system

The first question which we have to ask ourselves at this point is this: are air/ground communications adequate and do they satisfy the operational requirements? If I may be allowed to make a bold statement, I would say that they are not satisfactory, that they do not satisfy present requirements in some areas of high traffic density, and that they will most certainly be wholly inadequate in only a few years time when air traffic will have increased considerably and new types of aircraft will have appeared in the skies. Such a sweeping statement obviously needs elaboration.

There is substantial evidence from studies made in the last few years that the shortcomings of the air/ground communications are a major factor in the saturation of the air space as now experienced in several high density areas of the world. Further, it can be shown that the number of aircraft that can land per hour at busy airports is restricted not only because the air traffic services are inadequate, but perhaps still more because of the limited capacity of the air/ground communication system.

Air traffic controllers have to spend half their time on communication chores. This means that only 50% of their time is available for digesting the information collected and deciding on the coordinating action they should take, which is their primary function.

Studies made of communications during approach and landing showed that 50% of all

U.S. ground station in R/T communication with crews in the air.

air/ground talking concerned the communication process itself; identification, tests, acknowledgements, reports on reception etc. Overall redundancy[1] was found to reach the astonishingly high figure of 80%, indicating low efficiency in the exchange of information, but this was considered to be the price that had to be paid for practically error-free reception.

By far the greater part of the information that has to be exchanged between aircraft and the ground is stereotype and could be transmitted by more efficient methods of communication in a fraction of a second as compared to the several seconds, at least, required by telephony for simple "yes" or "no" information.

Of the inter-continental routes, those across the North Atlantic carry the most traffic and may be indicative of the conditions that will prevail on many other routes in the future. The speed of communications in general and the reliability of the air/ground communications in particular were major factors in determining the large separations between aircraft on North Atlantic routes which are necessary at the present time and cause grave concern because of their effect on regularity and economic operation of air traffic.

In radiotelephony communications for international aviation the problem of the language to be used is also a serious one. ICAO specifies that English should be used for international air/ground communications, pending development of an International Language for Aviation. Consequently, there are scores of pilots who have to use a language different from their own mother tongue, with all the problems inherent in such situations.

[1] Any communication consists of two parts, the real content which no artifice can compress further, and another, generally much larger, part made up of connecting words, special peculiarities of the language and the speaker concerned, repetitions to avoid confusion and so on. The aim of a highly efficient communications system must be to compress the second part as much as possible. The difference can be compared to the difference between ordinary handwriting and stenography. — Editors.

Pilot in R/T communication.

Scope of Improvements

Now a system which already contributes to the saturation of the air space and is a limiting factor in the number of aircraft that can be safely accepted in a given air space or can land per hour at busy airports can hardly be called adequate and efficient.

The realisation that air/ground communications need improvements has, of course, not come overnight; studies have been made for many years, and new systems have been devised in order to arrive at a more efficient exchange of information.

However, revolutionary changes in techniques and organizations seldom occur in one package, especially not in the international field; usually the change is gradual, introducing one new idea or equipment at a time until finally an entirely new system is in operation. Moreover, expensive and elaborate new equipment necessary to improve the efficiency of aviation in high density areas should not penalise too much the symbolic "Timbuctu National Airlines," flying once a day between two airports with a total number of fourteen movements per week. For many years to come "Timbuctu National Airlines" may be completely satisfied with one voice channel and should not be compelled to install 400-channel equipment, costly in procurement and maintenance.

Which way, then, do we go? It would seem that two phases can be distinguished; improvements to the present system of radiotelephony and the introduction of entirely new techniques. The two need not be in sequence, because new methods of communication may have to be introduced in some areas right away, while in other parts of the world this may not yet be practicable or desirable.

Several projects are under study or are being tested in actual practice, aimed at improving the radiotelephony system. Most of these concern the technical aspects of radiotelephony transmission, but others are of an administrative nature such as the efforts to streamline the procedures used in radiotelephony and insistence on rigid adherence to these procedures.

Of the technical projects, perhaps the most promising for the very near future is the installation of ground wave antennae at a number of suitable locations in the North Atlantic Region (Newfoundland, Greenland, Iceland, Ireland and Scotland). Ground wave stations exploit the propagation of a radio wave over the surface of sea water which can, with suitably located and constructed antennae, ensure reliable communication over distances up to 600 miles or more. This is of great importance during periods of ionospheric disturbances when normal transmissions (which rely on reflection from the ionosphere) suffer from distortion, fading, or complete interruption.

Another development which in its present form has a number of limited advantages is "selective calling". The present method of communication requires a continuous watch on the air/ground channels in order to detect individual calls. With selective calling, or "Selcal" as it is commonly called, this is no longer necessary because Selcal activates a visual and aural signal in the cockpit, indicating to the pilot that contact with the ground station should be made.

The quality of radiotelephony transmissions can be improved by various projects now under study. One of these envisages the use of a single side-band, instead of the present double side-band system[2], for the transmission of voice by a radio transmitter. However, the introduction of such a system for international aviation requires agreement on a number of elements and the earliest opportunity to obtain international coordination and agreement on

Ground wave antenna system at Prins Christianssund, Greenland.

[2] In all systems of radio communications, information is superimposed on a carrier frequency emitted by the transmitter. In the simplest case the information lies in equal parts in two symmetrical bands, one on either side of the carrier frequency, the so-called side-bands. At the reception end a single side-band suffices to extract the message. This is then known as single side-band transmission. However, it takes a relatively large amount of equipment at both transmitting and receiving ends such as is justified in particular for long-range commercial operations. In the usual double side-band system both transmitter and receiver are much simpler in construction. Editors.

the system characteristics seems to be the next session of ICAO's Communication Division, tentatively scheduled for late 1957.

The ever increasing demands of civil aviation for frequency channels has taken a heavy toll of the available frequencies; in fact, there is already a serious shortage in frequency channels in high density areas. In the high frequency (HF) bands little can be done to increase the number of channels, unless new communication systems would be introduced making a more efficient use of the frequency spectrum. For the very high frequency (VHF) bands ICAO agreements recognize the need for reducing the present channel spacing of 200 kc/s to 100 kc/s and in some areas of the world it is considered necessary to reduce this further to 50 kc/s. However, this latter spacing is not yet the subject of international agreement.

New Techniques

No amount of improvement in radiotelephony communications will be able to solve the problem of the exchange of information with the required speed in areas of high traffic density and in the vicinity of busy airports. In many other areas where radiotelephony is still adequate at the present time, this will no longer be so with increased traffic and the introduction of new and faster aircraft. For those areas nothing short of automation seems to be the answer.

For a very large portion of the information that has to be exchanged between aircraft and ground stations, automatic "data-transfer" is quite feasible with known techniques. The difficulty is that so many different systems are possible and have indeed been suggested during the last ten years. This is probably the main reason why agreement on what will ultimately be used is still lacking. Judging by what is known of developments and plans in various countries, it seems that something like the following is likely to happen.

One of the first practical measures to improve data-transfer for the purpose of providing the air traffic control services with better information is an increase in radar coverage (radar can be regarded as a data transfer system because it provides information about the position of aircraft). Expansion of radar installations to provide greater coverage is already in progress in a number of countries.

Next in line seems to be the installation of secondary radar, with which some of the shortcomings of primary radar can be overcome. With secondary radar the ground station interrogates the aircraft and triggers a reply from an airborne transponder. As transmissions are coded, the identity of the aircraft can be established without doubt, thus obviating the present cumbersome procedures necessary to determine the identity of aircraft observed

Typical control towers and flight information centres

Montreal control tower, Canada.

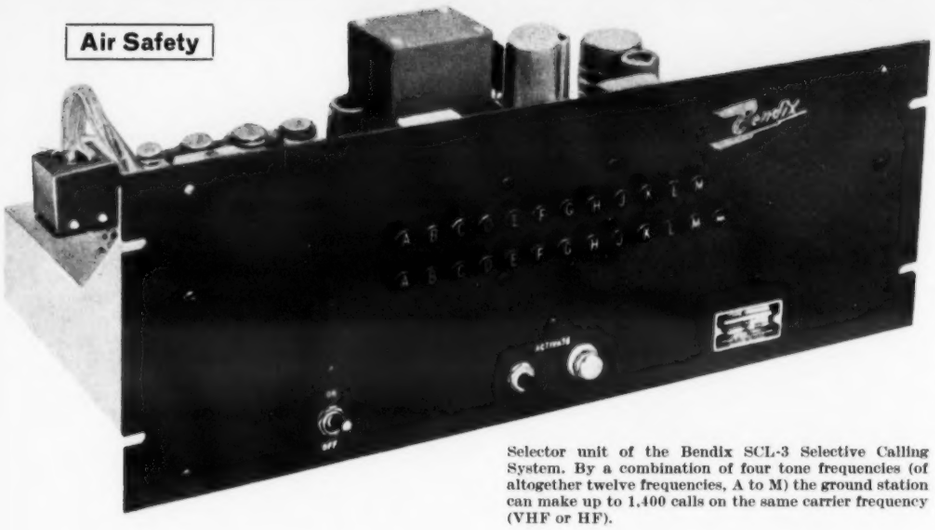
Paris-Orly control tower.

Beirut flight information centre, Lebanon.

Manila communications station, Philippines.

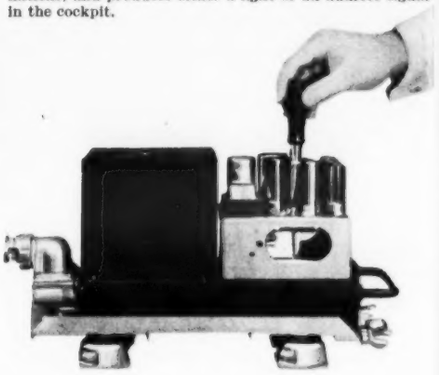
Lima communications station, Peru.

Air traffic controllers under training in R/T communications (I.C.A.O., Montreal).



Selector unit of the Bendix SCL-3 Selective Calling System. By a combination of four tone frequencies (of altogether twelve frequencies, A to M) the ground station can make up to 1,400 calls on the same carrier frequency (VHF or HF).

The receiving unit for the pilot (Bendix SCL-3A; here seen in dual arrangement) responds only to the tone frequency combination set (one of 1,400 possible combinations) and produces either a light or an audible signal in the cockpit.



on the radar scope. Primary and secondary radar can thus provide the ground stations, in a fraction of a second, with much information that otherwise would have to be passed by radiotelephony.

To increase also the speed of the transfer of information from the ground to the aircraft, various "signalling systems" have been devised, based on the automatic transmission of stereotype messages and instructions for visual display in the cockpit. A high percentage of stereotype messages, e. g., those containing holding and landing instructions, lends itself well for transmission by automatic signalling with visual display in the aircraft in some form or other. To give an idea of the speed with which such a system could work, one specification required that separate and distinct messages should be displayed to at least twenty aircraft within five seconds.

Ground-to-air signalling systems could be used for a variety of purposes, e. g., for a broadcast of meteorological data. A system for this function has been inaugurated recently on an experimental basis by a number of North Atlantic air carriers in collaboration with the British and Canadian Governments. Weather information is broadcast by two stations, in Newfoundland and in Scotland, using radioteletype. Since meteorological messages from ground to air form a considerable portion of the air/ground communication traffic, automatic reception in the aircraft of this information should relieve the radiotelephony channels of much traffic. Preliminary results of the tests show that a range of something like 900 miles can be obtained. Frequencies used are of the order of 120 kc/s, which has the additional advantage that reception remains stable and reliable during periods of ionospheric disturbances.

Apart from information on the position of aircraft derived from radar observations, there are other data that are frequently required from aircraft, such as altitude, distance to and bearing from a certain point (e. g. VOR), and course steered. If some or all of this information could alse be obtained by automatic means, a further step toward complete automation would be achieved.

The air/ground "data-link" has been developed to do this. Again various systems are possible but it seems that the most advanced is a system using transponders in the aircraft, activated by an interrogating signal from the ground. The information to be transmitted to the ground can be pre-set manually on the transponder by the pilot, or can be made entirely automatic by coupling low-torque flight instruments to the controls of the transponder.

It would be possible to organize the ground interrogating equipment so that, automatically, information from each aircraft in turn is obtained. Interrogation of one aircraft would take less than half a second, and if it were decided that information from each aircraft should be requested at one minute intervals, the capacity would be about 150 aircraft per minute.

Interrogation aerial of Cossor's secondary radar, mounted above the reflector for the Mark 6 primary radar (by the same maker), with which it rotates. Far right the primary radar's exciter unit.

Thus, gradually, the exchange of information between aircraft and the ground will shift from complete reliance on radiotelephony as at present, to a system of automatic signalling incorporated with an improved air traffic control organization. The need for voice communications will always remain, however, to take care of the exchange of random information of a type not suitable for automatic transmission.

Conclusion

If aviation were a slowly expanding industry where new developments could be introduced at leisure and where it would not matter if implementation were retarded for several years, there would not be cause for concern. However, aviation is expanding rapidly and it is not always too clear what the situation will be only a few years hence. Nevertheless, planning must be done because one thing is certain and that is that many of the present air navigation facilities will be inadequate in only a few years time.

Advance planning is necessary because States, airlines operators and the electronic industry will not commit themselves to the installation or production of costly new equipment if the exact system to be used is not known. Therefore, the date of implementation of new facilities is highly dependent upon the date at which agreement on functional and system characteristics is reached.

In the international field, where many countries may be involved, the period between reaching agreement on new techniques and equipment, and implementation thereof may be considerable; usually not less than several years because of budgetary and administrative reasons, training of personnel, availability of equipment and so on. Advance planning for the introduction of new equipment and facilities must be done therefore in the very near future if we are to view the future development of aviation with confidence.

Development Trends in Radio Navigation

by Dipl. Phys. Walter Stanner, Garmisch-Partenkirchen

There are many different methods of determining the most important navigation data—position, heading and distance, speed etc.—with the aid of electric waves, including D/F, distance measuring, hyperbolic and combination systems.[1] Probably none of these systems will ever reach the ideal state, as there appears to be an "unfathomable law" that aerodynamicists and engine makers should always be one step ahead of the high frequency engineers. At the end of the war it was possible to discuss in detail which of the systems then known should be retained in planning for the future. As the whole ground organization in Europe had been destroyed, the "best solution" could be sought. Today it would be difficult to find anybody who is satisfied with the results of the decisions and recommendations made at that time. Substantial amounts of money have meanwhile been invested in ground and airborne equipment, however, and these have yet to be amortized, so that even if an ideal system of radio navigation were developed it would take several years to get it into general use. The recent I.A.T.A. Technical Conference once again stressed the airlines' desire for new systems capable of meeting the requirements of the coming forms of air transport, though it did not go into details.

*

The use of *ground and airborne radar* is discussed elsewhere in this issue, so it need merely be briefly mentioned here. Radar is undoubtedly an excellent aid in air traffic control, Ground Controlled Approach, Airport Surface Movement Indication, storm and collision warning. As both transmitter and receiver are sited and operated together, no additional ground-air organization is required. In the available frequency bands, however, the cost and space problem forms the only serious handicap to a more extensive use of primary radar in aviation. The situation as regards *secondary radar*, on the other hand, is a great deal more complicated. Although its advantages are sufficiently well recognized, its introduction in civil aviation has so far been slow. Nevertheless no special prophetic gifts are needed to forecast that radar will have to be used much more widely if air transport is in future to achieve its maximum efficiency and reliability. Whether and to what extent the most recent developments, such as the transmission of radar images over long distances, screen tubes with colour reproduction etc., will play a part, cannot yet be predicted.

D/F systems

In the early days of radio navigation the *taking of bearings on airborne MF transmitters* was the only system technically feasible and therefore used throughout the world. Today it is virtually a thing of the past. *D/F equipment for HF waves* (Adcock), on the other hand, will continue to be a valuable additional aid for intercontinental operations, particularly in emergencies.

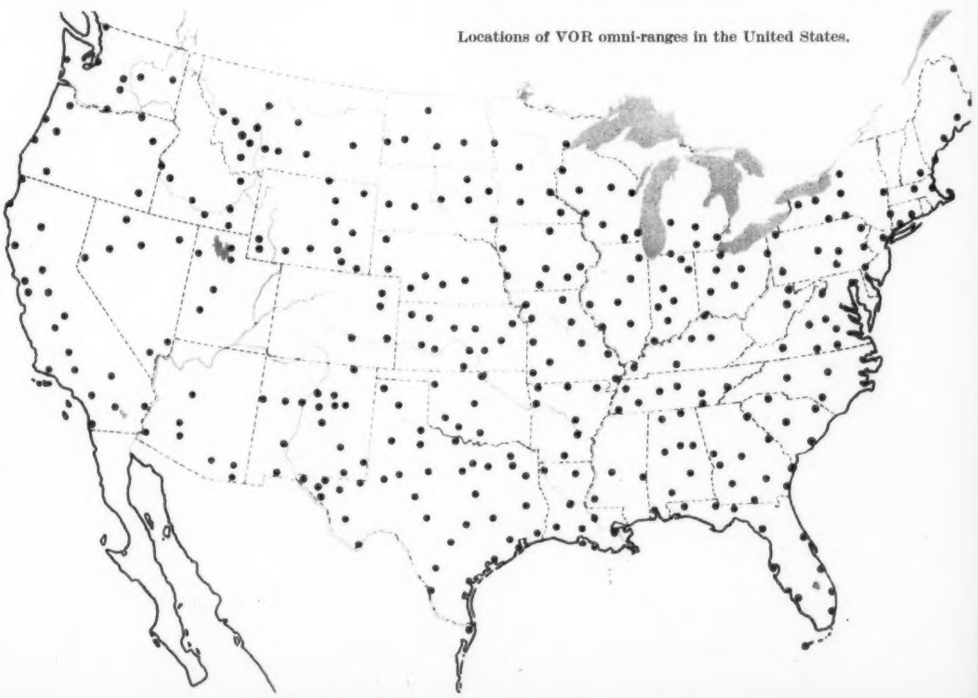
The use of *VHF D/F stations* to take bearings on R/T communications, provided automatic indication and interpretation are included. is frequently regarded as a useful means of checking the indications of the surveillance radar. Networks for this purpose are already being constructed in certain European countries. The first of 62 projected stations will be set up this year in the United States, but the remainder have had to give way temporarily to other priority tasks.

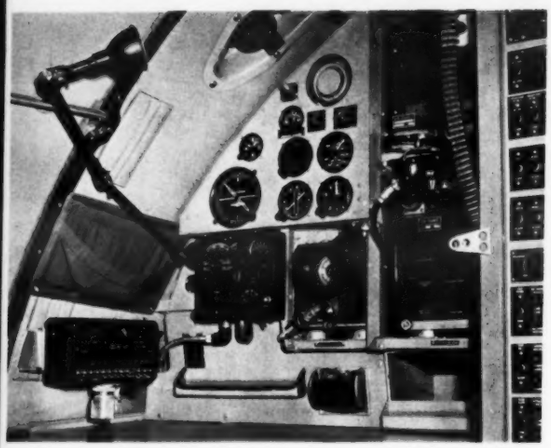
The system of *orientation on omnidirectional LF/MF radio beacons* probably also has only a few more years to live. There are still about 500 stations in operation in the Europe-Mediterranean region, and 173 in the United States. But the congestion in the band, the high incidence of atmospheric interference and the risk of error due to night effect make it less difficult to dispense with these frequencies . . . as soon as

[1] Cf. *W. Stanner:* "Physical Classification of Radio Aids to Navigation," in *International Hydrographic Review*, Vol. XXXI (1954).

Collins VOR ground station (in this case for Terminal VOR = TVOR). Single or dual transmitters of 50 or 200 Watt can be used.

Locations of VOR omni-ranges in the United States.





Navigator's post in an Air France *Super Constellation*. Far right the Loran equipment with visor for easier setting.

adequate VHF facilities are available. They will retain a certain value as reserve facilities during a protracted transition period, especially on less densely operated routes. Thus every effort must continue to be made to improve the airborne equipment (radio compasses) as regards reliability, bulk and weight, and combined reading.

Directional beacons

Four-course LF/MF beacons (radio ranges) were—and to a certain extent still are—a popular and particularly simple navigation aid. In the United States, for example, there were no fewer than 323 installations in service in 1941, a figure which rose to 378 in 1949 but has fallen to 347 in 1956. Today homing on a given course with indication of left and right deviations can be accomplished more reliably by other systems, so that the directional beacons are gradually taking a back seat. By 1959 there will be only 120 left in the United States. In the Europe-Mediterranean region there are still about 60 radio ranges in operation, but these will also be withdrawn gradually, as soon as sufficient VHF aids are available. *VHF directional beacons for en route navigation* (such as VAR) will also probably lose their value after the general introduction of VHF omnidirectional ranges. On the other hand the combination of VHF directional beacons (the result of a development begun in 1928) known as the Instrument Landing System has established itself, along with GCA, as a provisional final solution for landing in bad weather. According to a C.A.A. report there were 157 ILS installations in service in the United States in 1955, and a further 13 were planned for early completion. By 1958–59 there are to be 185, and by 1960–61 the figure should reach 198. During the next few years the United States is to replace some of the older glide path aerials with new improved models. It is also planned to improve the marker beacons and to modify the localizer aerials so that approach can be made from either direction. ILS installations, some of them of the latest models[2], are also in use at the major European airports. Airborne receivers and indicators are offered in various combinations. Although ILS has overcome most of the difficulties involved in bad weather landings, there is still a great deal to be done, through further improvements to the equipment, increases in reliability and training of personnel, before approach to an airport can be made under all weather conditions.[3]

Rotating beacons

As stated above, the trend today is towards replacement of the airborne D/F equipment or radio compass with *electronic phase measurement of the azimuth*. The principle of taking bearings on a radio station remains, but the major part of the effort is transferred to the ground station. Moreover, no additional communications are needed, so that personnel can be economized. Among the particularly numerous proposals for rotating beacons, C.A.A.'s system for frequencies around 100 mc/s (VOR), originally proposed in 1937, has so far made the most headway. Equipment of the U.S. airways with these beacons began in 1946; by mid-1955 there were 410 stations in operation, and another 88 were planned. Work is also progressing in Western Europe, and contracts for the erection of VOR stations on the Far East routes have been placed. However, there is still no such thing as a coherent network, such as is necessary in view of the limited range of VHF waves, anywhere outside the United States.

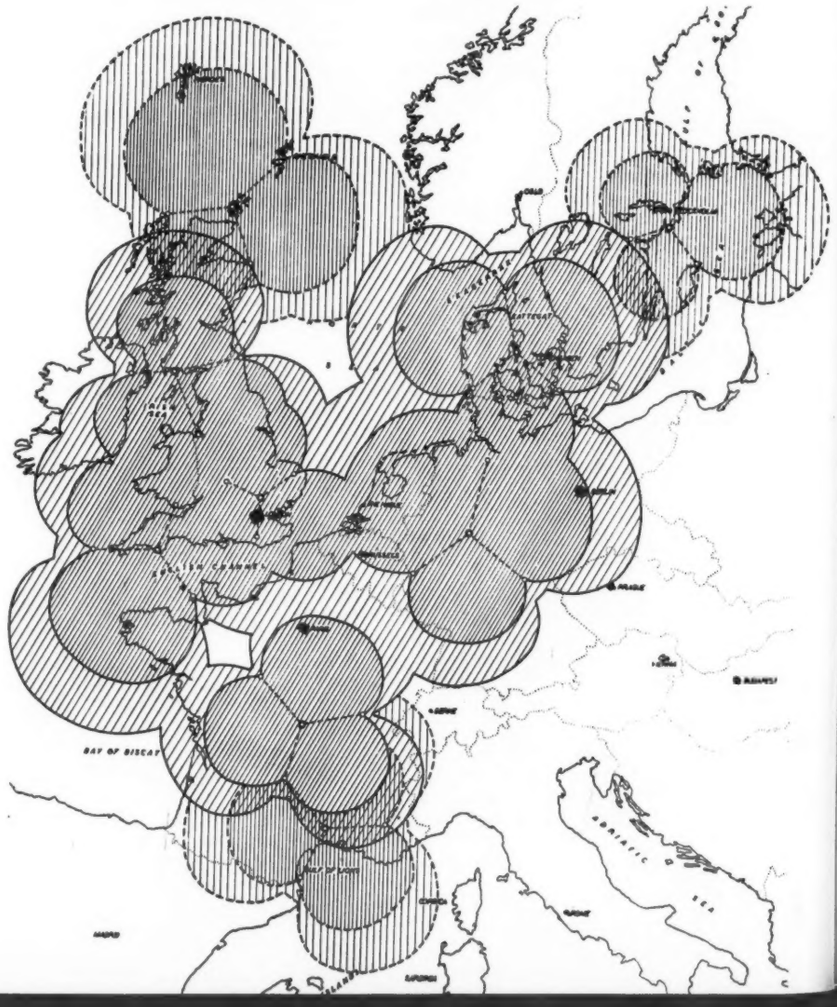
Distance measuring

VOR provides the azimuth to the ground station concerned, in relation to magnetic north. The combination of the omnidirectional beacon with some other system to provide distance for polar coordinate navigation[4] is becoming an urgent need. Original plans envisaged the *Distance Measuring Equipment* (DME) on 1,000 mc/s. DME ground stations are sited alongside VOR transmitters, but operate quite independently of the latter. In June 1955, the United States had 214 DME ground stations in use,

[2] Cf. *K. Bärner:* "Theorie und Technik des Instrumenten-Landesystems," in *Luftfahrttechnik*, No. 5, 1955, pp. 74-88.

[3] Cf. *A. Fischer:* "Flight Cancelled . . " in *Interavia* No. 4, 1954, pp. 215-219.

[4] Polar coordinates are angle Θ between North and the line joining the aircraft and the ground station, and distance ρ of the aircraft from the station. We therefore also speak of a Rho/Theta system.



Coverage of the European region provided by the Decca Navigator System and curve showing accuracy at night during the summer half-year (95 % values); oblique shading applies to existing chains, vertical shading to chains under construction.

another 141 installed but not yet commissionned, and 73 on order. Further development had to be suspended temporarily, however, as the frequencies needed for DME in the 1,000 mc/s band overlap with the *TACAN system*. The latter is an advance on the VOR/DME combination in that both azimuth and distance can be determined by the same system. The sad result of the *DME/TACAN* controversy is that, though there are two highly valuable systems for measuring distance, neither is likely to be available to users during the next few years. Until a decision is made as to which system is to be ultimately adopted, the many ingenious proposals for off-course computers and pictorial presentation of position data, in conjunction with the airborne distance measuring equipment, will have to be shelved.

The military predecessors of distance measuring equipment, such as *Shoran* and *Oboe,* have demonstrated the high degree of accuracy obtainable by this principle. Later developments, such as the British 200 mc/s transponder made by Murphy, are available in at least some areas. On the whole, however, navigation by polar coordinates, which is claimed by many competent sources to have particular advantages, including clear presentation and easy flyability, will not be introduced generally for some time, for organizational reasons.

Airborne equipment for the Decca Navigator System (Flight Log and Decometers) in the cockpit of B.E.A. *Viscount* G-AMNY (Captain Linstead and First Officer D. H. Coleman).

Long base-line systems

Consol: The German-designed Consol stations give very accurate position line determination, using the ordinary airborne receiver. This is achieved through a skillful combination of the equi-signal principle—known since the early beginnings of radio navigation—with beam rotation and dot-dash keying, and the use of a wide aerial spacing. Distances between the outer aerials are between 4.4 and 5.7 wavelengths. The 266–319 kc/s frequency band used, however, raises the well-known difficulties of atmospheric interference, congestion, night effect. The simplicity and accuracy of the system resulted not only in the stations at Stavanger (Norway), Lugo and Seville (Spain) being retained in operation after the war, but also in new stations being built at Bushmills (Northern Ireland) and Ploneis (France). Under a recent plan the rest of the North Atlantic area is also to be provided with Consol stations. Reports collected by I.C.A.O. from a number of airlines[5] indicate that the Consol stations, though never planned for today's North Atlantic routes, still supply useful assistance for certain navigation problems. However, the primitive and time-consuming counting procedure is more suitable for slow fishing boats than for high-speed airliners, and though recording equipment is now available to do the troublesome counting for the pilot, there remains the problem of time and of ambiguities. Proposals to eliminate the inadequacies of the system by modifying the aerials[6] have had no response. Nevertheless, C.A.A. tests with a higher-powered Consol station at Allaire, N. J., and with special receivers show that, if suitably developed, the proven Consol system could definitely hold its own with more recent systems.

Loran: The wide coverage provided by Loran at the end of the war, its very long range and high degree of accuracy seemed to predestine the system for world-wide adoption. This, however, has not been the case, and some stations have even been dismantled. Despite I.C.A.O. recommendations, nothing more has been heard recently of the previously much discussed LF Loran stations, or of SS-Loran. The development of new, more reliable receivers with greatly simplified methods of setting and reading the figures for the navigation charts and introduction of improved transmitters have made the best possible use of existing facilities so that Loran still forms the backbone of long-distance navigation.

Decca Navigator: Although not introduced until after the war, this system is in widespread use in various applications. The six chains in Europe are being supplemented by three more in Northern Scotland, the South of France and Sweden, and there are one each near Bombay and Calcutta, India. The new *Mark X* airborne equipment has been designed with special reference to aviation requirements. The Flight Log has been made lighter and smaller and is in full use by B.E.A. To complete the picture it should be mentioned that the Decca Navigator system is also of great value in helicopter operation and shipping.

Dectra: This is a recent system specially developed from the above for the North Atlantic. According to an announcement by the Canadian Department of Transport, the four stations required will be completed in 1956–57, two of them near Prestwick, Scotland, one at Comfort Bay, Canada and the fourth on Thonborn Lake, near Gander. The Dectra system provides both homing and distance measuring in the LF range. For the latter purpose not only the time difference between the signals from the transmitters on either side of the Atlantic is measured but also an absolute time measurement is provided: the use of a highly constant oscillator applies to radio navigation one of the few remaining physical principles not hitherto utilized.

Other systems: Hyperbolic navigation on *GEE chains* is still in use in the British Isles and has been further perfected by the introduction of improved transmitters and the development of simpler airborne indicators. The *Navaglobe* and *Navarho* long-distance systems have completed the experimental stage, but are still not sufficiently advanced for general introduction. The *Radio-Mailles* (Gaudillère) system is still undergoing tests and cannot be assessed until the results are available.

[5] Cf. *I.C.A.O. Circular 46-AN 41:* "Information Concerning the Long Distance Radio Navigation Aid Consol."

[6] Cf. *E. Kramar:* "Omni-Ranges for Long Distance Navigation," in *Interavia* No. 3, 1952, pp. 159-162.

A Five-Year Plan for the American Airway System[1]

The control of air traffic in the United States is a Federal responsibility and comes within the competencies of the Civil Aeronautics Administration, Department of Commerce. What is officially known as the Federal Airway System consists of all the facilities and services essential to safe and efficient flight in all weather conditions, such as visual and electronic aids to navigation and landing, air-to-ground and point-to-point communications, dissemination of weather information and notices to airmen, and the control of air traffic at airports and on heavily travelled routes. At joint civil-military airports it includes the terminal navigation aids and traffic control services. Finally the air route control centres also have to take care of military aircraft that take off and land at purely military bases (where they use military landing aids and control installations) but must fly over land and thus utilize the airway system.

When drawn on the map, the U.S. airway system is by no means a network of fine lines. On the contrary there are wide areas around the big population centres, particularly in the Northeast (the Chicago – Detroit – Pittsburgh – Indianapolis quadrilateral and the wide band between Washington and Boston), in the Southwest (north and south of Fort Worth) and the West (Los Angeles and San Francisco regions). These areas of particularly heavy traffic are controlled by eleven of the present 26 Air Route Traffic Control Centers.

*

The C.A.A. plan for the airway system during the next five fiscal years states from the outset that important parts of the Federal Airway System are overloaded: "In significant areas, the volume and nature of the traffic are such that the airway facilities and services cannot assure its efficient flow in bad weather. This simply means that, where safety requires it, instrument traffic is delayed or cancelled; people are delayed; and the aircraft operator—private, commercial or military—suffers loss in money or accomplishment of mission."

Moreover, the need for *en route control of traffic in good weather* is becoming increasingly apparent, as higher speeds and the great increase in traffic volume augment collision hazards.

The improvement of the traffic control system is thus an acute problem. So that it should not become a chronic problem as well, the C.A.A. has submitted to Congress a detailed plan calling for the investment of large sums in new facilities. In total, $246,192,000 are to be spent during the next five years, in addition to operating and maintenance costs ($111,000,000 to $173,000,000 annually) and personnel charges. In particular, the following new installations or extensions to existing facilities are planned:

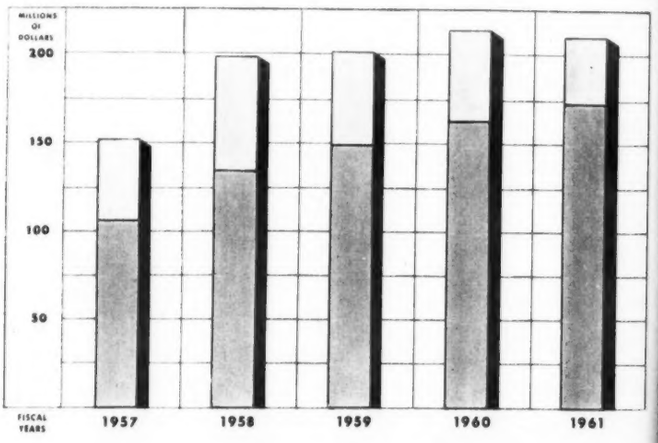
To this not inconsiderable expenditure on ground equipment, the funds for which will have to be found by the taxpayer, must be added the cost of new equipment for the aircraft, e.g., VOR/DME or TACAN receiver/transmitter and secondary radar equipment, which the civil and military operator will have to bear. The alternative facing the U.S. Congress and the aircraft operator is clear and inexorable: either they must put their hand in their pocket and pay up handsomely for the necessary navigation and surveillance equipment... or accept increasingly frequent delays, re-routings to other airports or even flight cancellations!

The main emphasis in the C.A.A. plan is clearly placed on the *VOR stations* (881 of which are to be in operation by 1961) and on *long-range radar stations* (range 130 nautical miles), which will be integrated with the military air traffic control system. The report states expressly that the latter must be provided in sufficient quantity for the controller to be able to dispense with the present fix postings and supervise the whole traffic direct on the radar scopes at the ARTC centres.

In his foreword to "Federal Airway Plan", C. J. Lowen, C.A.A. Administrator, calls upon research and industry to increase their efforts, in particular in the field of *automatic control displays and other devices*. The controller should be relieved as far as possible of all subsidiary work so that he can concentrate all his attention on making important decisions.

[1] "*Federal Airway Plan, Fiscal Years 1957-1961*", published by the U.S. Department of Commerce, Civil Aeronautics Administration; for sale by the Department of Commerce, Washington 25, D. C.

Facility or service	In service by end 1956	For completion by 1961	Cost ($)
Airport control towers	186	40	3,354,000
Traffic coordinating equipment	—	—	25,000,000
Airport surveillance radar	45	44	17,061,000
Airport surface detection equipment	—	20	5,000,000
Approach lighting systems	25	187	11,360,000
D/F equipment	60	100	750,000
High altitude control of airspace	—	—	1,580,000
ILS systems (and DME)	170[1])	28	4,529,000
Long range radar (incl. Air Defense Command)	4	69	39,536,000
Omniranges (and DME)	498	383[2])	44,828,000
Precision approach radar	22	20	6,000,000
Secondary radar	—	134	14,771,000
Modernization of facilities	—	—	72,423,000
Total			246,192,000



Money the sine qua non of airways safety: C.A.A. has asked the U.S. Congress to appropriate funds for the installation (light shading) and operation (dark shading) of additional navigation and control aids during the 1957 to 1961 fiscal years.

[1] Includes DME at only 22 stations

[2] DME *not* included in 1957 plan (... because of the TACAN controversy. - Editors).

ONE of the
advanced engineering features
assuring high reliability in

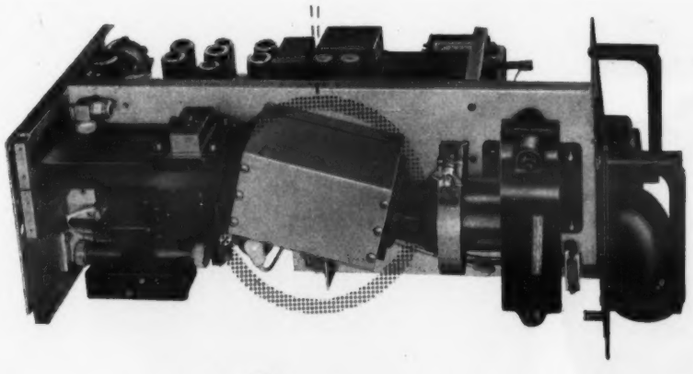
COLLINS WEATHER RADAR

This component in the RT unit of Collins WP-101 Airborne Weather Radar System is a load isolator. Its function is to allow the magnetron to operate into transmission lines having less critical characteristics which otherwise must be corrected by complicated line tuning.

The load isolator also protects the magnetron from high VSWR conditions caused by accidental damage to the wave-guide. Generally this damage is detected only by a series of successive magnetron failures—an expensive procedure in both time and money. It all adds up to an extra measure of reliability engineered into Collins Weather Radar System.

There are many other advanced engineering features in the WP-101 system, including: simplified circuitry; printed wiring, which connects and supports components, adding strength without weight penalty; reduced tube count; modular construction throughout, for maximum serviceability.

For complete information, write for Collins WP-101 brochure.



Collins

CREATIVE LEADERSHIP IN AVIATION ELECTRONICS

COLLINS RADIO COMPANY, CEDAR RAPIDS, IOWA, U.S.A.
COLLINS RADIO COMPANY OF ENGLAND, LTD., Sunflex Works, Colham Mill Road, West Drayton Middlesex, England

A LINE OF 3000

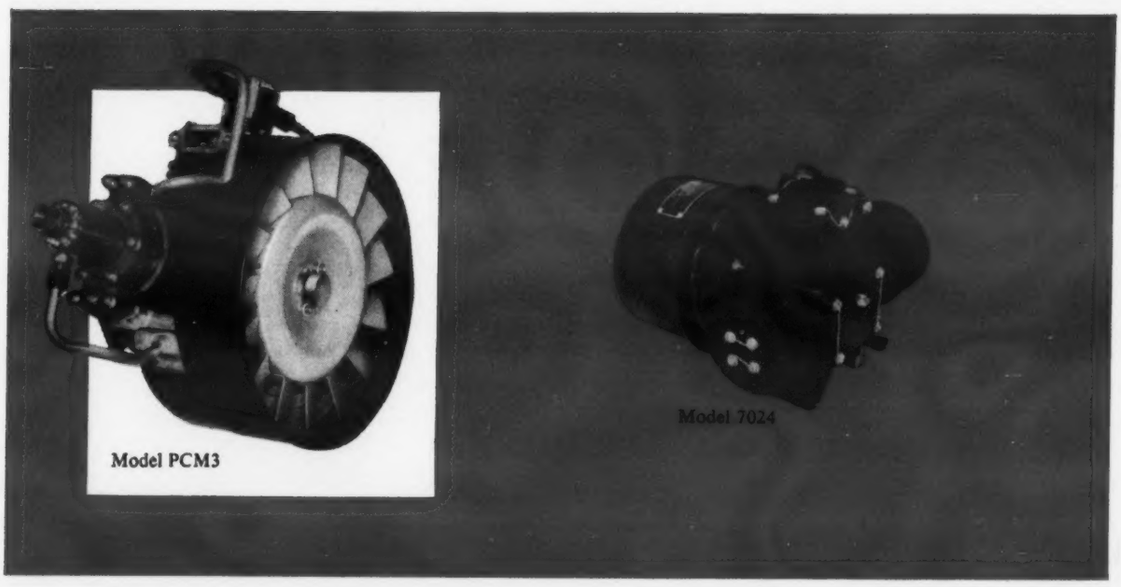
DELIVERING FROM 1.8

Stratos compressors for high pressure pneumatic systems cover a wide range of rated volume delivery and applications.

Models are available either as complete packages, or as basic compressors only. Complete units include electric or hydraulic motors, interstage coolers, moisture separators and automatic controls. Certain models can be ordered with or without controls, with provisions for a variety of drives—electric, hydraulic or turbine. For the basic units, controls and ancillary equipment such as pre-coolers and after-coolers can be provided to match the specific aircraft requirements.

Installation of the packages is simple, requiring only four mounting bolts and connecting to the high pressure air lines and electric or hydraulic service of the aircraft. Automatic controls, standard equipment on all compressor packages, provide a minimum pressure differential of 100 psi between shut-off and turn-on pressures. The allowable shut-off pressure range is 2950 to 3050 psig, and the allowable turn-on pressure range is 2700 to 2950 psig. A relief valve prevents overpressurization.

Light and compact, each compressor is designed to operate over a wide temperature range—from 65° to 165° F. Integral cooling fans are standard equipment on all units.

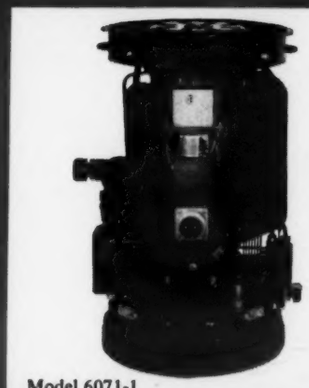


Model PCM3

Model 7024

PSI COMPRESSORS

TO 16 SCFM by STRATOS



Model 6071-1

Model 7023

BASIC MODELS

PCM3 **Delivery—from 7 to 16 SCFM**
Nominal rating—11.2 SCFM @ 15 PSI inlet
No fall-off with altitude when pressurization is available
Controls and moisture separator available
Suitable for electric, hydraulic or turbine drive
Weight 21 lbs. without motor.

7023 **Delivery—2.4 SCFM**
Complete package including controls, moisture separator and 400 cycle motor
Weight complete 33⅛ lbs.

7040 **Delivery—2.4 SCFM**
Complete package including controls and moisture separator
Constant speed 3 gpm hydraulic motor operates on 2200 to 3000 psig
When operating under 80° F, full rated output is maintained from sea level to 10,000 ft.
Weight complete 30 lbs.

7034 **Delivery—2 SCFM**
Complete package including controls, moisture separator and 400 cycle motor
When operating under 80° F, full rated output is maintained from sea level to 10,000 ft.
Weight complete 33⅛ lbs.

7038 **Delivery—2 SCFM**
Controls not included – can be provided as a separate package • Hydraulic motor drive
Inlet can be pressurized • Weight 11 lbs.

6071-1 **Delivery—1.8 SCFM**
Complete package including controls moisture separator and DC motor.
Weight complete 37¾ lbs.

7039 **Delivery—1.8 SCFM**
Complete package including controls and moisture separator
Constant speed 3 gpm hydraulic motor operates on 2200 to 3000 psig
Weight complete 29⅛ lbs.

7024 **(available soon) Delivery—1.8 SCFM**
A simplified 3-stage compressor with 400 cycle motor.
Incorporates pressure regulator.
Other controls available.

For more complete data on Stratos' compressors write to: Stratos' Western Branch: 1800 Rosecrans Ave., Manhattan Beach, Calif.

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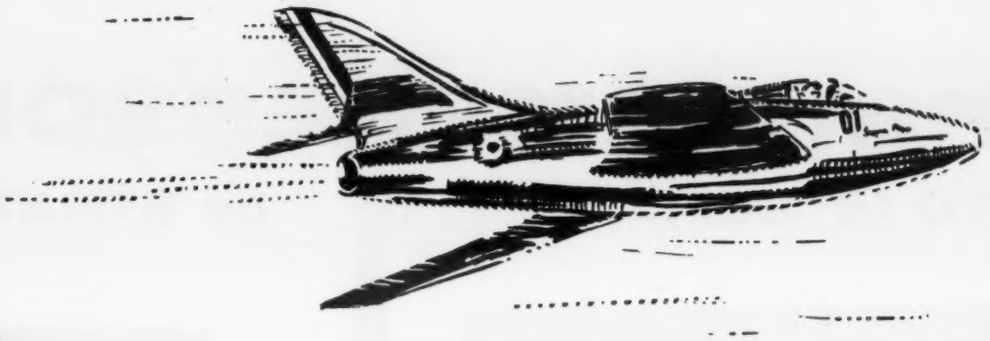


The only European aircraft with SUPERSONIC SPEED in LEVEL FLIGHT ordered in quantity:

Super-Mystère B2

Designing for Aircraft Safety

BY M. CARL HADDON

CHIEF ENGINEER, CALIFORNIA DIVISION, LOCKHEED AIRCRAFT CORPORATION

M. Carl Haddon, 47, Chief Engineer of the California Division of Lockheed Aircraft Corporation, supervises technical aspects of the Division's engineering operations. Haddon went to work for Lockheed in 1940 as a senior design engineer following a career in aviation dating from 1931, when he was awarded a Bachelor of Science degree in aeronautical engineering from the University of Michigan. His pre-Lockheed experience was at Keystone Aircraft, Briston, Pa.; American Airplane and Engine, Farmingdale, Long Island; Consolidated Aircraft, Buffalo, N.Y.; Stinson Aircraft, Wayne, Mich.; Stearman-Hammond Aircraft, South San Francisco; and Svenska Aeroplan A.B., Linköping, Sweden.

Haddon was appointed a group engineer on the XB-30 within five months after joining Lockheed and two months later was project engineer on the XP-38A twin-boom fighter. In 1952 he became the California Division Chief Project Engineer, following 10 years of project work, mostly on the *Constellation* series; and was advanced earlier this year to the position of Chief Engineer.

The safety of the airline passenger depends primarily on the safety of the aircraft, how well it is designed, manufactured, maintained and operated. A recognition of the importance of these factors is exemplified in modern engineering's approach to design for safety: specifically, from a design standpoint, safety is achieved by superior *performance, reliability* and *controllability.*

Our latest design can be used to illustrate the company's engineering approach to designing for aircraft safety. The new Lockheed *Electra* is a 64–90 passenger four-engine turboprop transport cruising at speeds in excess of 400 m.p.h.

*

Let us first consider performance as it contributes to safety. Extra performance margins in the high power of turboprop engines mean additional safety from the ability to take off in short distances and climb at a high rate after take-off. At take-off speeds, the propeller still remains the most efficient and versatile device known for converting engine power to propulsive effort.[1]

Wing area has to be selected for landing performance. In the *Electra* choice of span to go with that area resulted from an optimization study relating high and low-aspect ratio, and involving considerations of cruise efficiency, wing weight and fuel tankage. All these were considered, and an aspect ratio of 7.5 was chosen as the optimum for the desired missions of the airplane. To illustrate, in normal operating conditions the *Electra* can land in less than 5,000 feet. The structure of the *Electra* is designed to permit landings up to 95,650 pounds. This weight was chosen to permit the airplane to take off again without refueling, with a payload of 18,000 pounds, and fly another 750 miles against a 50–m.p.h. headwind.

Rate of descent of the *Electra* is comparable to that of currently operating airplanes in normal approach; and a wide selection of safe descent rates is made possible by *incorporation of a dive brake.* In addition, the airplane incorporates large Lockheed-Fowler wing flaps (60 per cent span, 43-inch chord) which contribute to high lift characteristics, low landing speeds and short field operations—all elements of safety through performance.

Further to the point of performance, the *Electra* is designed to have plenty of power available when it is needed. With three of its four engines operating, the airplane will maintain altitude of over 15,000 feet at normal engine power and slightly more than 100,000-pound weights. With two engines out on the same side, the *Electra* at an average cruise condition of 90,000 pounds can maintain flight at altitudes up to 13,000 feet; and at maximum takeoff weight the airplane will operate successfully at 7,000 feet on any two engines.

*

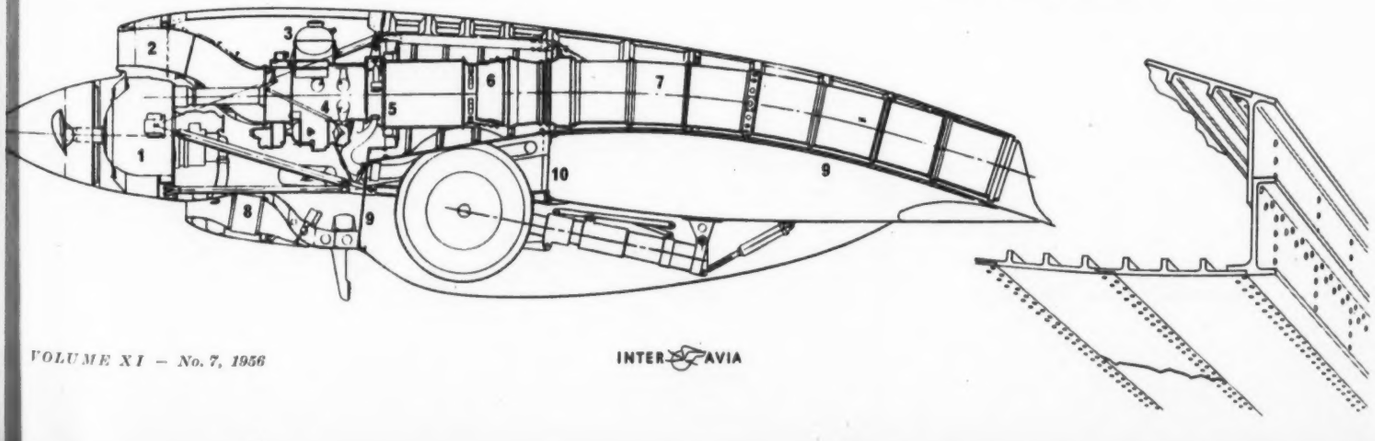
Of equal importance to performance is the factor of reliability—reliability of the structure, the power plant, and the various systems.

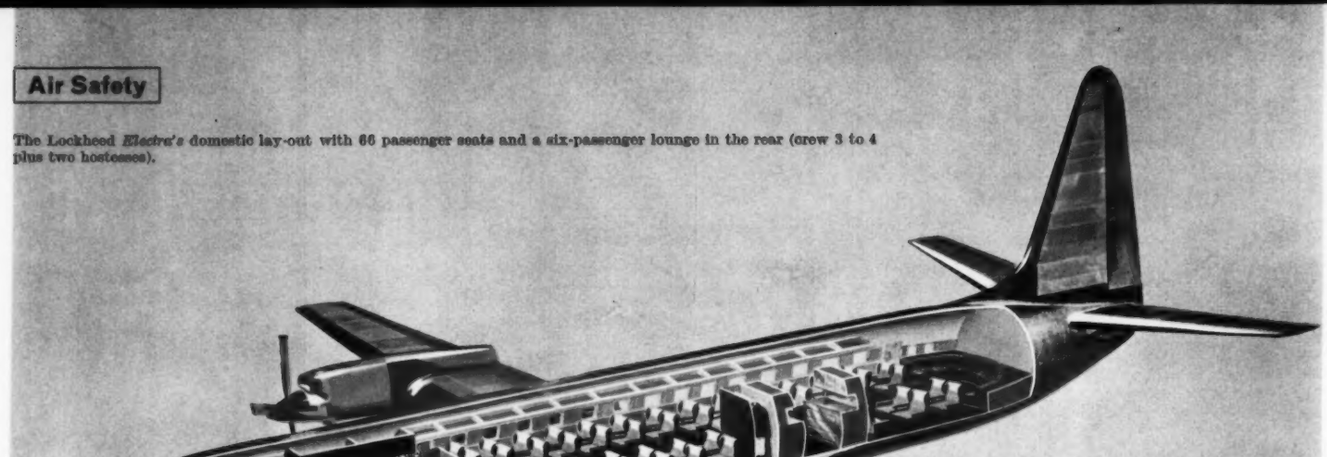
Lockheed work on the *fail-safe principle* constitutes one of the most interesting aspects of the *Electra* design—especially as it relates to structure. A fail-safe structure is one which provides dual safety, making only an incident of what otherwise might become a catastrophe. Under the fail-safe philosophy, the designer provides for a structural arrangement so that no single failure will produce catastrophic results, designing to stop tears and cracks in the fuselage, arranging rings and beams in fashion to reinforce each other, and verifying design criteria by preliminary laboratory work and final testing. Thus the point is to provide

[1] For example, at 100,000-pound gross weights, the *Electra* can take-off in 4,050 feet to clear a 50-foot obstacle on a sea level-standard day. More than 95 per cent of U.S. domestic flights would be at weights less than 100,000 pounds. For extreme range flights, the *Electra* is designed to take-off with as much as 113,000 pounds gross weight. The take-off distance at this weight is 5,430 feet.

"Built-in safety" for engines and landing gear: the extra performance margin of the turboprops cuts down take-off distance and raises rate of climb after takeoff; air induction scoops are placed as high as possible to avoid ingestion of foreign bodies; the landing gear is of the free-fall type and is self-locking. 1 – gear box; 2 – air intake; 3 – oil tank; 4 – compressor; 5 – fire seal; 6 – turbine; 7 – tailpipe; 8 – oil cooler; 9 – firewall; 10 – front spar.

"Built-in safety" for wing unit: composed of integrally stiffened surfaces, the *Electra's* wing box beam is a prime example of the "fail-safe" principle. If a crack originates at any point of the skin, it can propagate only across its own panel. The remaining panels have sufficient strength to support flight loads.





The Lockheed *Electra's* domestic lay-out with 66 passenger seats and a six-passenger lounge in the rear (crew 3 to 4 plus two hostesses).

multi-load paths that act very much like the many strands in a steel cable: if one strand fails, there are many more to take up the load.

This fail-safe design technique was based on wide experience with the *Constellation* family which proved that an airplane can overcome tremendous difficulties—even midair collision or penetration of a pressurized fuselage. The company's policy has been to limit allowable stresses to conservative values where fluctuating stress levels might lead to fatigue. Following observations from experience, we took the basic idea of fail-safe into the laboratory and refined the principle by research into many different materials, different structural shapes, and all sorts of varied temperature and other conditions that an airplane might encounter. For example, the wing box beam is composed of extruded and machined integrally stiffened surface supported by truss-type ribs, and each surface is broken into spanwise panel strips. If a crack should originate in and propagate across any one panel, the remaining panels have sufficient strength to support flight loads without failure.

Safety-through-reliability is further exemplified by the following features: double windshield posts; fuselage skins made from 24ST sheets; reinforcements and large radii at corners of all cutouts.

All pressure doors open inward, positively preventing accidental opening in flight. Cabin windows are double construction.

One of the static tests will be "axe tests" in which remote control axes will slash into a pressurized *Electra* fuselage in about 50 different places, proof-testing the airplane to see that the structure will not rip or tear to catastrophic proportion if fatigue or other cracks should appear.

In addition to fail-safe, reliability is obtained by close attention to details of the power plant installation and airplane systems. In the design of the power plants, the air induction scoops were placed as high as possible, with the gear box located below the centerline of the engine to minimize the ingestion of pebbles, sand and other foreign material into the engine.

The flaps have a dual reliability in that they are hooked into both hydraulic systems. The configuration of the hydraulic system itself incorporates a safety principle of importance. The all-electric-driven hydraulic pumps are controlled independently of the engines, and hydraulic power is not associated with possible engine power loss. Should one hydraulic pump fail, it can be shut off by a flick of the switch. With the dual system, and the reliability of boosters and flaps, dropping out a pump does not affect the flight characteristics and controllability. This is a novel concept in design, and one reason it comes about is the electrical system arrangement.

For the tremendous amount of electrical power available on the Electra, we depend on four engine-driven 60 KVA a.c. generators which produce 208/120 volt, three-phase, 400 cycle constant frequency alternating current. This system is set

Main data for the Electra

(Power plant: four Allison 510-D13 turboprops of 3,750 s.h.p. take-off power each)

Span	99 ft.
Length	104.5 ft.
Height	32.1 ft.
Track	31.2 ft.
Wing area	1,300 sq.ft.
Wing sweep	0°
Aspect ratio	7.5
Max. gross weight	113,000 lbs.
Max. landing weight	95,650 lbs.
Takeoff wing loading	87 lbs./sq.ft.
Takeoff power loading	7.5 lbs./h.p.
Passenger capacity	64—90

Weight empty	56,000 lbs.
Operating weight	59,370 lbs.
Normal payload	17,720 lbs.
Max. stage fuel	28,710 lbs.
Reserve fuel	7,200 lbs.
Total	113,000 lbs.
Guaranteed cruising speed at 22,000 ft.	405 m.p.h.
Max. still air range	2,830 miles
CAA takeoff airport length (for 106,700 lbs.)	5,250 ft.
CAA landing airport length (for 85,500 lbs.)	4,960 ft.

up for three busses, with the fourth a.c. generator capable of being switched to any of these busses in the event of failure or loss of an engine. Further, any two of the generators may be lost and the priority electrical loads are maintained.—As is generally known, the a.c. motors are far superior in reliability, serviceability, simplicity of construction and low weight over previously used d.c. motors.

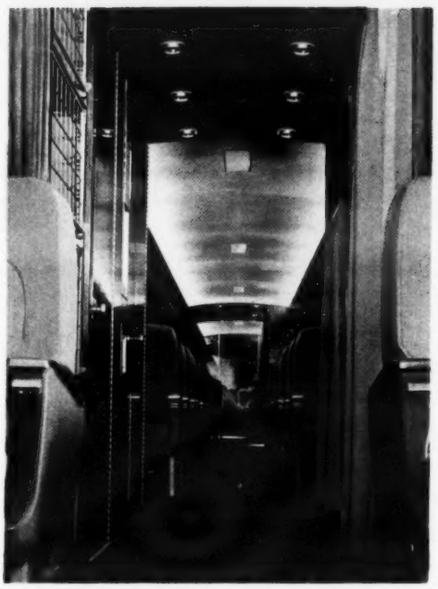
Another point of high reliability exists in the fact that the landing gear is of the free-fall type in both main and nose positions, for a straight drop-and-lock operation.

Great improvements have been made in the field of fire detection and extinguishing, and a significant new feature of the *Electra* system relates to the crew operated fire extinguisher controls. These are so designed that for each engine, pulling a single lever shuts off all combustible fluids and air to that engine and automatically prepares for discharge of one of two bottles of fire-extinguishing foam to that particular engine.

To eliminate any type of combustion heater, Lockheed designed for the use of heat compression from the engine-driven cabin compressors, supplementing this with electrically heated panels in cabin floors and sidewalls. This is significant in that combustion-type heaters are always a problem—another source of potential fire.

*

Safety also depends on maintaining the airplane properly; and maintenance in turn depends on good accessibility to various aircraft systems and their components. Lockheed engineering designed for maximum access by grouping the electrical and hydraulic components in service centers in the *Electra's* lower fuselage-centers that can be readily entered by a mechanic in a standing position. Here all the components requiring attention and checkout are centralized. Hinge-type cowling is provided for easy access to the engine-driven components, as well as removable panels for inspection of the engine burner-turbine section. Adequate inspection doors are provided strategically throughout the remainder of the airplane. The leading edge of the wing is hinged between the inboard nacelles and the fuselage and between the nacelles for easy access in these areas.



Inside the mock-up of the 66-seat domestic version; in rear, the lounge.

*

Along with superior performance and reliability comes design for safe controllability of the airplane. Lockheed gave long and serious study to means of achieving optimum controllability on the *Electra.* Certainly we had to face the possible effects of sudden engine failure which, without proper design and suitable precaution, could cause trouble. To prevent high propeller drag on loss of engine power, the propellers incorporate a number of automatic and independently operating mechanical safety features, including a negative torque sensor, a decoupler, and blade angle follow-up. In addition, a thrust actuated autofeathering device is operative on take-off. These devices are all independent of each other and the failure of one has no effect on the operation of the others.

For added safety through controllability, the hydraulic system incorporates several design safety features. The surface controls are powered by two independent hydraulic systems that are in no way hooked together. In the remote possibility that both systems should go out completely, the aircraft is designed to be controlled by mechanical means by shifting to a lower ratio of stick force.

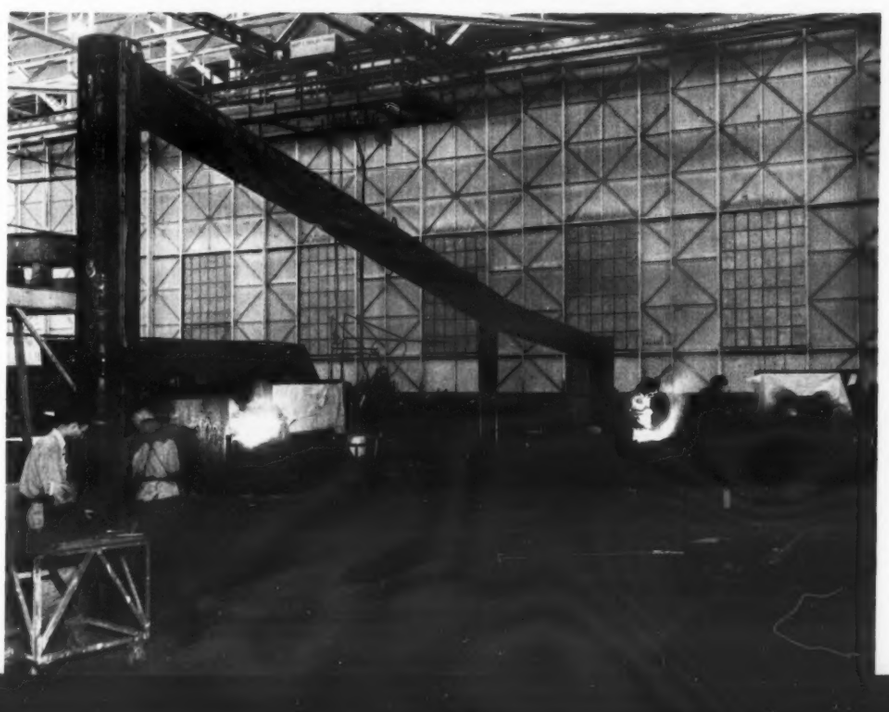
Yet another phase of controllability concerns the weather. The *Electra* was designed to operate in continuous maximum and intermittent maximum ice as defined by the C.A.A., a goal which is being achieved by the use of a combination of electrically heated elements and heat from the engine compressor bleed. The electrically heated elements include the vertical and horizontal stabilizer, propellers, and windshield, while engine bleed air is used on air induction scoops and leading edges of the wing. Additionally, weather radar is available for skirting those areas of high ice accumulation.

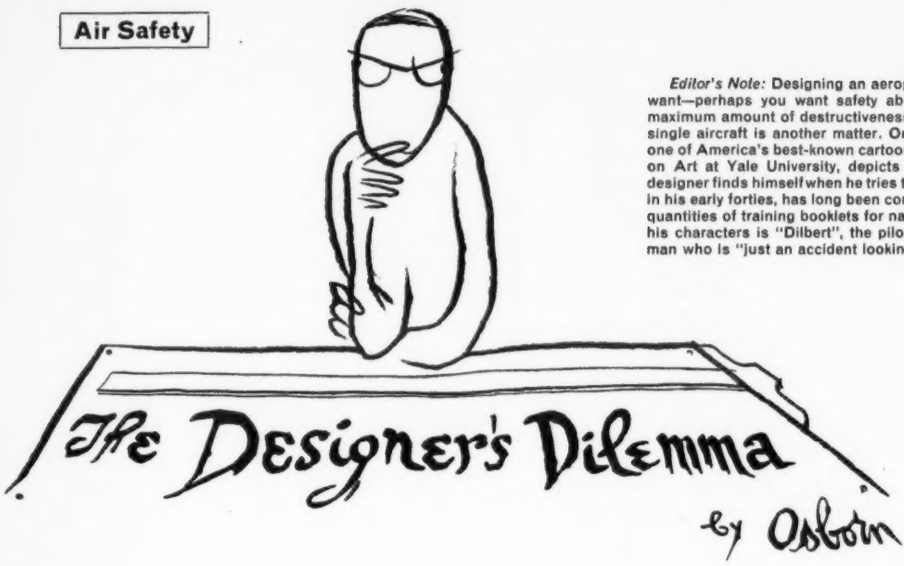
Little has been said here directly about that *sine qua non* of aviation safety, the flight crew. Their importance is well understood and recognized by everyone who flies. We have drawn freely on the experience of our own pilots as well as those of the customer airlines and the Air Line Pilots Association in the development of the *Electra* flight station. The whole concept of cockpit arrangement is one of simplicity and accessibility. Large windshields permit excellent range of vision, including 15° down visibility.

*

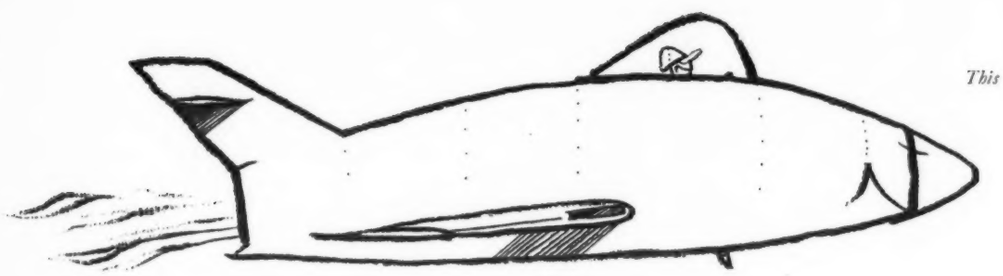
In this brief report are but a few of the means by which—through superior performance, reliability and control—designers can provide the airlines with a transport for greater passenger safety than yesterday.

Precision work is the foundation of safety: assembling a wing jig for the Lockheed *Electra*

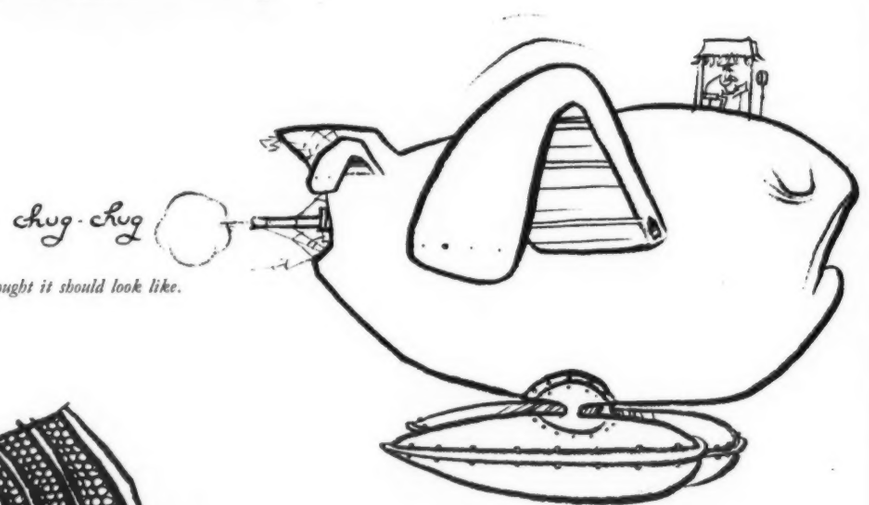




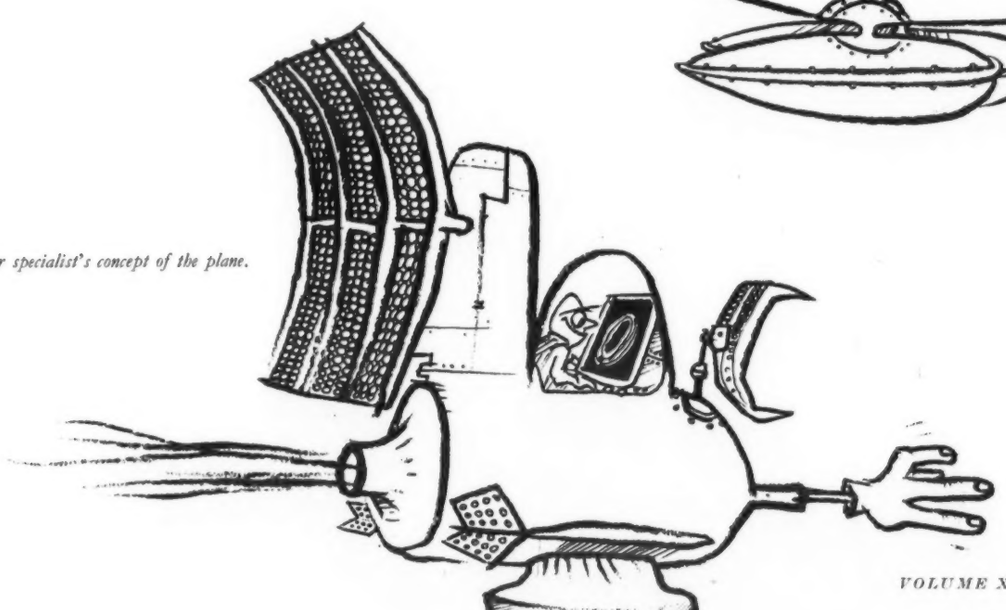
Editor's Note: Designing an aeroplane is easy if you know what you want—perhaps you want safety above all, or range, or speed, or a maximum amount of destructiveness. But to get all these features in a single aircraft is another matter. On these two pages Robert Osborn, one of America's best-known cartoonists, head of the Graduate Council on Art at Yale University, depicts the dilemma in which an aircraft designer finds himself when he tries to satisfy all the specialists. Osborn, in his early forties, has long been connected with aviation and produced quantities of training booklets for naval aviators during the war. One of his characters is "Dilbert", the pilot who always makes mistakes, the man who is "just an accident looking for a place to happen."



This is what the design should have looked like.



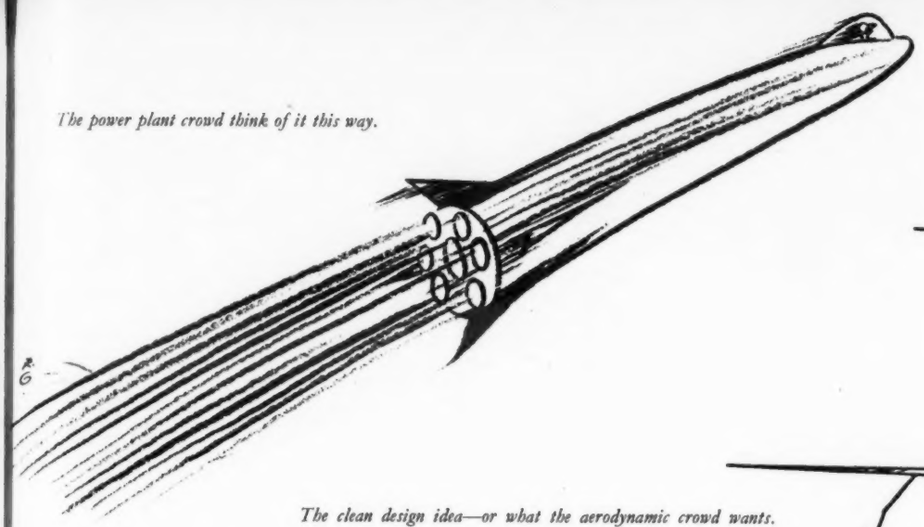
This is what the long-range (or fuel) experts thought it should look like.



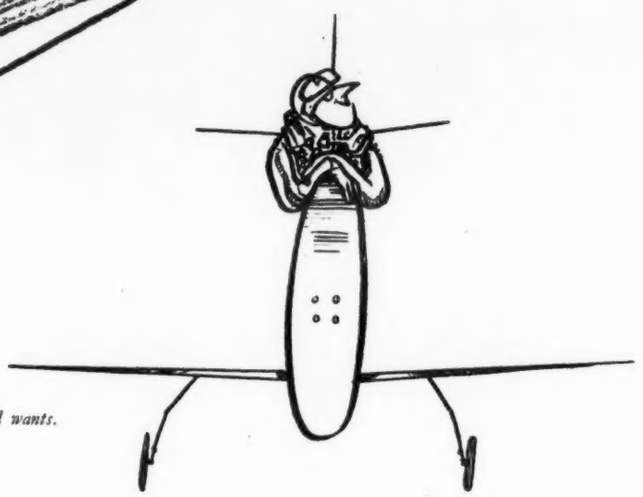
The radar specialist's concept of the plane.

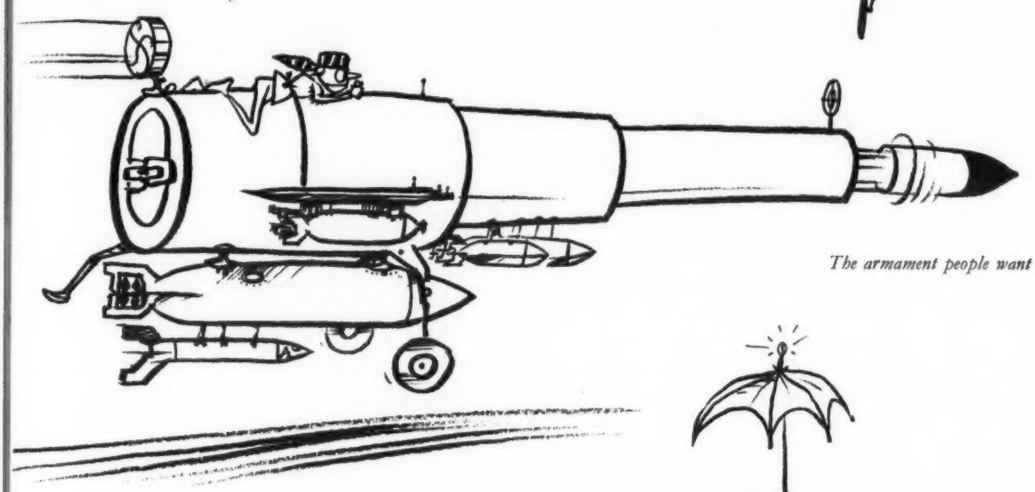
Osborn

The power plant crowd think of it this way.

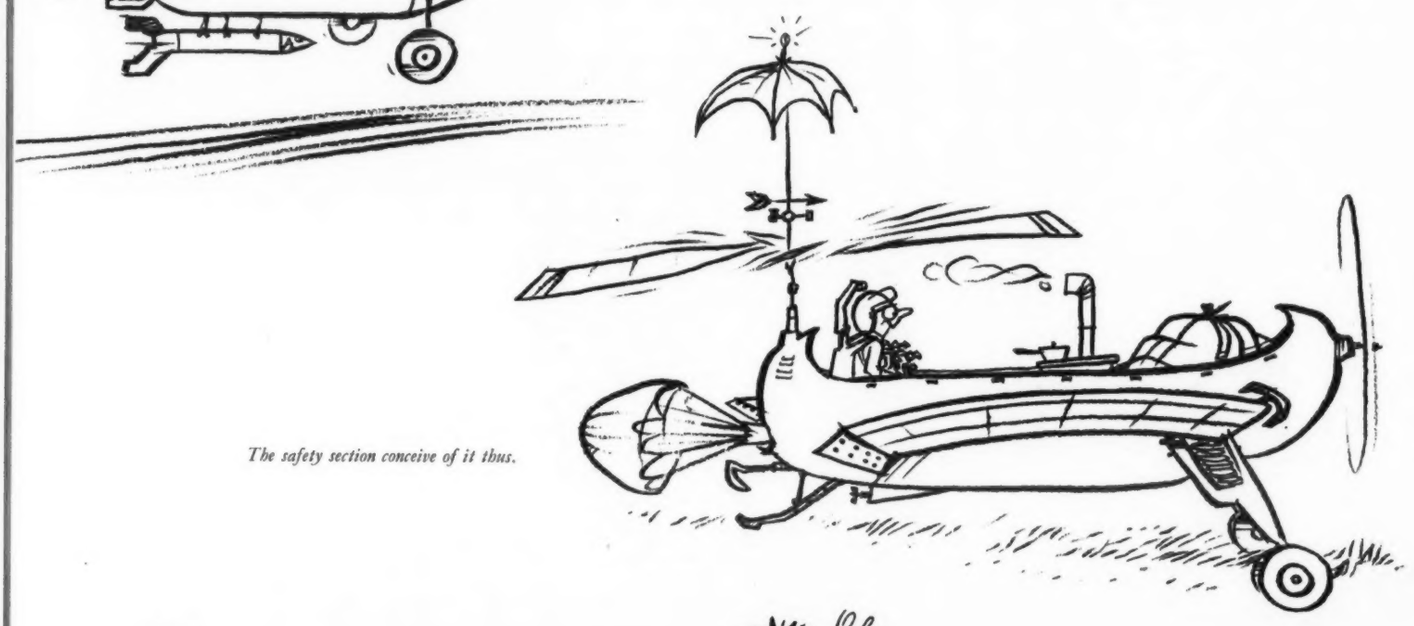


The clean design idea—or what the aerodynamic crowd wants.

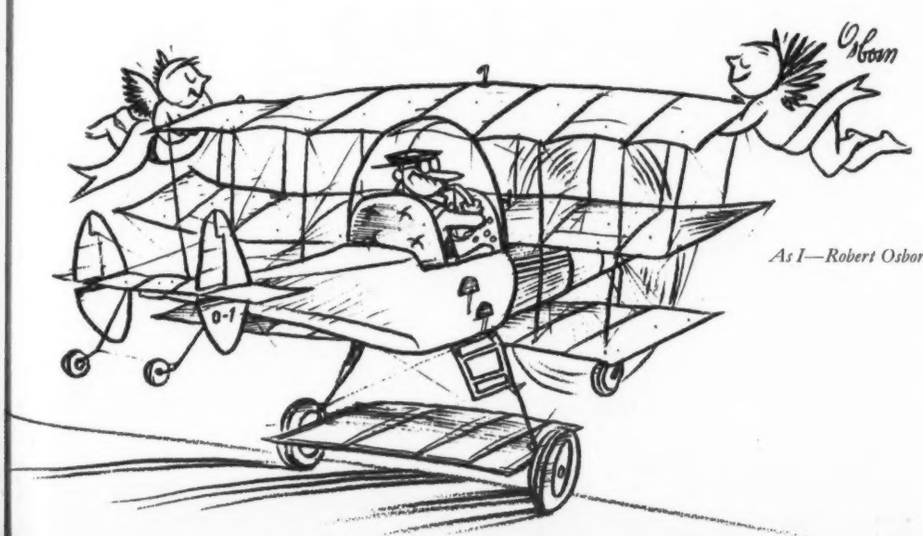




The armament people want it to look like this!



The safety section conceive of it thus.



As I—Robert Osborn—would design it (Osborn's Pleasure Craft!)

Air Safety

Lockheed Super Constellation *Star of the Seine* en route.

Training Air Crews for Safety

BY BEN NICKS

TRANS WORLD AIRLINES, KANSAS CITY

High above the storm-tossed Atlantic a big four-engined airliner bores its way through the thin air of the sub-stratosphere. For the past hour Flight 914, bound from New York to Paris, has been skirting the bubbling cumulo-nimbus thunderheads pushed up to flight level by the passage of a cold front far below.

With a slight touch on the controls of the *Super Constellation,* the Trans World Airline's captain deftly swings the aircraft a few degrees to the right, a degree left. He intently peers at a small five-inch dial, brilliantly illuminated in the dark and quiet cockpit of the airliner. The plane rumbles through the lightning streaked night, plunging into the inky black heart of a massively towering cloud, out again, into another.

Inside the cabin, half a hundred passengers relax comfortably, a few curiously peering out into the dark at the spectacular pageant, but most of them sound asleep, lulled into drowsiness by the hum of the engines and swaying of the plane.

A TWA air crew—captain, copilot, flight engineer, two air hostesses.

In due course the *Super Constellation* breaks into the clear moonlight beyond the squall line of the cold front. It steadies down to a solid pace, seemingly hung motionless in the star spangled night. The captain flips a switch to black out the instrument he had been observing so intently for so long.

"Radar," he muses, partially to his copilot but more to himself, "is wonderful. We penetrated that front without losing 10 miles." The captain is right, of course. Weather radar is wonderful. A couple of years ago the same frontal penetration might have taken the flight several hundred miles off course and still have resulted in a severe shaking of plane, crew and passengers as it inadvertently pierced a turbulent storm cloud.

What the captain didn't mention, however, is the long hours of training and practice he spent in learning how to read and operate this new flight operation tool. Technical progress made in aeronautical engineering, electronics, communication and a hundred allied fields must be matched by the skill of the men who use the fruit of these advances.

"It's an old saw," says Bert Cooper, Manager of Training for T.W.A., "but it holds true more in our business than any other. A tool is no better than its operator."

Keeping pilots acquainted with the tools of their trade and proficient in their use is Cooper's job, himself a veteran airline pilot and nine years head of T.W.A.'s flight training department. He recalls that when he first joined the company in 1939 he received a brief and sketchy course in the "duties of a copilot" and was assigned a run with an experienced captain. While on the job he learned the airline's operating methods and became acquainted with the airplane. This "hit and miss" technique of pilot training had been the industry's standard procedure ever since the first aviation entrepreneur scraped together two planes and called it an airline. It was to remain the accepted practice well into the early 40's.

As World War II closed, however, airline training departments were substantially enlarged to process the flood of newly hired pilots. Most of them were fresh from several years of military service in the war and required a briefing in the methods of commercial airline flying.

Even today most of T.W.A.'s pilots are recruited from the military ranks and are competent professionals when hired. This is also true of the airline's flight radio officers and navigators. Initial training for these groups stresses familiarization with civil aviation procedures and equipment.

T.W.A. has found it necessary to train its own flight engineers, however, converting themfrom experienced airplane mechanics into proficient airborne technicians in a five month course.

"The theory of flight hasn't changed since the days of the Wright brothers. You still pull the stick back to climb, and coordinate on turns. Practically anybody can get a plane into the air and back on the ground again with a few hours of instruction. But it takes a smart, well trained professional today to know his plane from nose wheel to rudder, to know the operation of every vital system and how to use this knowledge to maintain complete, safe control over his aircraft at all times despite any possible circumstance that may arise. A pilot may fly his entire career and not encounter a single serious non-routine operation. But he's been trained and drilled over and over to meet any eventuality that could possibly happen. If he should need that bit of knowledge in a pinch, he has it."

T.W.A. spends several millions of dollars a year in recruiting and training flight crew members. Training is a never ending process

for pilots, flight engineers, navigators and radio operators. All crewmen return dozens of times to the school, located at Kansas City, Mo., municipal airport to keep abreast of the latest developments in navigation and flying aids. Every time a pilot checks out on a new aircraft, or if he transfers from domestic to international flights or vice-versa, it means back to school and intensive study.

The most experienced captain, veteran of 25,000 hours in the air across oceans and continents, must take a regular six month's proficiency check aloft, just as the newest copilot on the line.

When hired the new copilot receives a thorough nine week ground and flight school instruction course, including some actual time on the line as a student copilot, before he is assigned to a regular schedule where he gains operational experience and knowledge of airline procedures, under the direction of an experienced captain for several months. He must complete a 16-month home study course and pass periodic examinations. New procedures and techniques are bulletined to him at regular intervals and his proficiency is noted by expert check pilots.

After an apprenticeship of eight to ten years as a copilot, flying the line regularly under direction of experienced veterans, he is considered ready to move over to the left seat as an airline captain. The upgrading course takes about five months, including periods of flying the line under supervision of instructor pilots interspersed with ground school classes.

Throughout his career as an airline captain, he will receive constant training in flight simulators, proficiency checks, emergency drill, instrument training and physical examinations.

The flight engineer is another important member of the crew. The complexity of modern flight operation requires that the pilot be freed from many of the routine duties of monitoring performance of the aircraft's systems. The flight engineer, with controls and instruments located at his station, requires intensive training in interpretation and coordination. He, too, receives additional instruction in T.W.A.'s ground school at Kansas City whenever he changes from one type of equipment to another.

"Teamwork is the keynote of crew training," Cooper declared. "Each individual is taught his own highly specialized duties until he knows them backwards and forwards. Then he is meshed into the entire crew operation as an efficient unit in a precision machine."

Cooper cited the airplane's check list as an example of teamwork among the crew members. "The copilot has the job of reading aloud from a prepared list items that must be accurately checked before take-off or landing.

"For instance, on the Super-G Constellation, the copilot reads 22 items to the captain and 24 items to the engineer before starting the engines. These include such things as lights, radio, fuel, propeller pitch, mixture control, landing gear, flaps and others. Each duty must be performed and acknowledged aloud by the individual responsible for its proper operation.

"The copilot has other check lists to call out after starting engines, on engine run up, at take-off, before landing, after landing and when leaving the cockpit. In all, the copilot calls for 133 items to be checked by the captain or flight engineer. This is a routine procedure that has been drilled into every pilot and engineer from the first time he straps on a seat belt as a crew member."

Several years ago most instruction was of the "lecture and blackboard" type, or carried out on the aircraft itself. Today wide use is made of actual working models of different systems, slides, flight duplicators for instrument training, tape recorders, movies and other training aids. "Practically anything that can be taught in the air can be taught better on the ground

Glimpse into the cockpit. Flight engineer at his controls in foreground, copilot in the right-hand pilot seat.

with the proper equipment," Cooper states. "We are now in process of receiving three multi-million dollar flight simulators which we can use to train entire crews on the ground, giving them all the illusion of flight aloft—including engine sound. This permits intensive training in emergency procedures in perfect safety on the ground, and permits us to drill again and again on these procedures."

T.W.A. uses color movies for flight route familiarization of crews. This technique is a recent development in the industry, and its proponents claim that pilots receive more benefit through this procedure than under the former method of actually flying the course under guidance of an instructor. "A pilot can study a movie leisurely, running through it several times if necessary," Cooper said.

Movies were also used to train pilots on use of the weather radar instrument. Selected pictures were compiled showing operation of the electronic storm detector under many varying conditions. "A pilot could hunt for months all over the western hemisphere for actual storm conditions to view on his radar scope," Cooper said, "but we showed him films of all types of actual weather conditions in minutes."

Such attention to detail and thoroughness of training crews pays off in a smoother and safer ride for passengers. Those Paris bound travelers who slept through a raging storm over the Atlantic were blissfully unaware of the long hours of practice their captain expended on the study and interpretation of the glowing picture puzzle on his tiny radar scope. The captain, too, probably passed it over without much thought as his aircraft sped toward France. After all, as a highly qualified professional, it's his job.

TWA Super Constellation *Star of Windsor* makes a refuelling stop.

Air Safety

A Simulator for Training G.C.A. Controllers

BY G. MANUEL
HEAD OF THE ECOLE NATIONALE DE L'AVIATION CIVILE, PARIS

Among all the civil navigation systems designed to facilitate approach and landing, G.C.A. has probably made the biggest contribution towards freeing air transport from restrictions imposed by bad weather. As a result, safety and regularity have greatly benefited.

But G.C.A. cannot simply be regarded as serving isolated aircraft. The growing density of traffic in the terminal areas of major airports and the constantly increasing speed of aircraft necessitate increasingly accurate control of air traffic and a continuous, instantaneous picture of the situation. These requirements are admirably met, within its range, by G.C.A. surveillance radar, which enables traffic to be accelerated, to the advantage of both airlines and their passengers.

Finally, G.C.A. is the system which involves the smallest number of problems as regards airborne equipment, a feature particularly appreciated by the operator.

Its use, however, means that the pilot must abdicate some of his responsibility to the controller in charge of the landing, who alone is qualified to judge the situation and to take decisions, at any rate until just before the final moment.

Such close interdependence demands perfect training of the radar controller. Only adequate training will ensure correct approach manœuvres, enable full use to be made of the equipment's capabilities and engender the degree of confidence in the pilot without which the operation cannot succeed. Moreover, if confidence is to be complete, it must extend to the whole team of radar controllers at an airport. "Stars" may be useful in exceptional cases, but regular teamwork is much more important.

Here a delicate problem arises, that of training controllers capable of assuming the heavy responsibilities involved in an aircraft landing. Firstly the lives of the 55 or 90 or even—as will soon be the case—130 passengers are at stake; secondly there are financial responsibilities, since a *Super Constellation* costs about $2,000,000 and a Boeing 707 will cost more than $5,000,000; finally there are what may be called operational responsibilities, the economic outcome of which, though less spectacular, may be heavy for the airlines: if traffic is heavy and there is a hold-up, a missed landing may easily entail 30 minutes of extra flying, costing about $500 in a *Super Constellation*.

These responsibilities are very similar in nature to those of the pilot. Such similarity is unfortunate in one sense, since the cost of training a pilot is extremely high, so that, though on a smaller scale, the practical training of a radar controller is proportionately costly.

*

One of the tasks entrusted to the *Ecole Nationale de l'Aviation Civile* is the training of all personnel for the air traffic control services, including, of course, the civil G.C.A. controllers. Up to this year, their training took place chiefly "on the job" at Orly and Le Bourget, a method generally condemned today as being too slow, not efficient enough and likely to make pilots lose their confidence.

A possible alternative was to use aircraft, but as more than 300 approaches and landings are considered necessary to train a controller from scratch, the cost is obviously high,

Radar scopes for a G.C.A. installation. Right, the surveillance portion; left, the precision approach portion in dual arrangement.

The instructor's post with control desk and monitoring scopes.

running into several million francs per controller. It can be reduced by using smaller aircraft, but this method is not satisfactory, since the radar image must remain clearly visible on the screen, and, what is more, the manoeuvrability of the aircraft used for training must not differ too greatly from that of the heavy transports that will be encountered later. Costs can also be cut down by reducing the amount of "dead time" and increasing the number of landings per hour of flight. But the volume of traffic at both Orly and Le Bourget is such that it would be difficult to complete the whole operation in less than fifteen minutes. Altogether, then, such a method of training would be extremely costly, hence the idea of using a device to produce simulated echoes.

A complete electronic simulator combining a landing scope and a surveillance scope was specially built for the School by Compagnie des Compteurs. Final adjustments were completed recently, and the equipment has already been used successfully on a first course. This preliminary course was, of course, followed by a practical course at the airport using airliners on normal services and practice aircraft. It is still too early to calculate exactly the savings that can be made by the simulator, but they will certainly be substantial. The results obtained during the practical course now being taken by students having started on the simulator already testify to the efficiency of the method and suggest that the number of real approaches needed for training can be cut down by half.

*

In designing the simulator, the main preoccupation was to place the student in working conditions as close as possible to those which he will encounter at the airport. The equipment provided requires of him the same kind of adjustment operations—brightness, centring and calibration, orientation of aerials etc. The impression given on the surveillance radar scope is that four aircraft are operating simultaneously within a radius of thirty miles of the airport. The elevation and azimuth scopes of the landing radar show two aircraft simultaneously, cover a range of twelve miles and simulate one landing every three minutes.

*

The "instructional" part of the simulator comprises the actual generator of the echoes with its control desks and monitoring scopes. An instructor, or a student under his supervision, plays the role of pilot, with two sets of controls. One is for the approach manoeuvre, which is followed on the panoramic screen by the student controller; it includes controls for heading and speed—which can vary between 60 and 600 miles per hour—and a control for the aircraft's radius of turn with provision for stacking. The other set is for landing and includes, in addition to horizontal speed and heading controls, an extra control for rate of descent or climb.

The position of the simulated aircraft and of the radar echoes it produces is determined in azimuth and elevation by the direction of a pivoting arm with travelling cursor. The distance of the cursor from the axis of rotation is measured by a resistance and corresponds to the aircraft's distance from the ground station.

The instructor can produce simulated permanent echoes on the screen such as would be caused by fixed obstructions around a given airport. When a "landing" has been completed, he can quickly return the "aircraft" to its point of departure, ready to begin a new exercise. Further improvements are also under consideration, including a control to simulate drift as a function of wind force and direction.

*

Each simulated aircraft consists of a cursor which travels over a horizontal plate and moves with it an arm pivoted about a vertical axis representing the station. The aircraft's distance from the station is measured by the resistance of a strip of metal along the arm. The arm's position shows the azimuth of the aircraft, and the measurement is made when a rotating contact, pivoting about the same axis as the arm and synchronized with the movement of the simulated aerial, reaches a fixed contact on the arm.

The position of the aircraft in the horizontal plane is determined in the same way for both surveillance and precision approach radar, but in the latter case there is the added problem of elevation. This is determined by a simple electronic calculator from the aircraft's known distance from the ground station and its altitude in relation to the latter. When the simulated aircraft appears in the landing zone, it has an altitude selected in advance by the instructor, who is also in constant control of the rate of descent. An integrator in the computer then provides from these data the aircraft's altitude at any given moment.

*

The apparatus* has been developed jointly by engineers from Compagnie des Compteurs and the Ecole Nationale de l'Aviation Civile, assisted by Paris G.C.A. controllers and experienced pilots. It will be able to render great services to civil aviation, in the training not only of G.C.A. controllers but also of personnel for the approach and regional control centres, where radar will find increasing use in the years to come, in view of the constant growth in traffic volume and of the coming introduction of jet transports.

In view of the cost of the simulator and its high "output" (roughly twenty-five G.C.A. controllers a year, a figure that is well above the average annual requirement for civil aviation in many Western European countries), it might be suggested that the training of radar controllers is one field in which international cooperation would be particularly valuable.

* The latest in a whole series of simulators in use at the School for the rapid and efficient training in approach, airport and regional control methods, D/F etc.

Esprit de Corps also Plays its Part

BY GUSTAVE JEAN LEFÈVRE, PARIS

Safety of course depends on the correct functioning of every part of a complex whole: engines, radio equipment on the ground and in the air etc... It also depends on careful selection and meticulous training of the men to whom the aircraft are entrusted, whether air or ground crews...

All these factors undoubtedly play their part, but at times, when material aids fail, the *esprit de corps* of the flying fraternity steps in and prevents disaster.

A small example will illustrate better than the lengthiest explanation this amazing sense of solidarity. A few months ago a U.S. Air Force C-119, having lost its way over the Paris area and with its radio compass out of order, was guided almost hand in hand down to the runway by an aircraft of the French night mail service.

The story is told below by the pilot of the latter aircraft himself, in his own matter-of-fact style.

Report on incident to FBCYU and U.S.A.F. C-119 8254.
Capt. Baxter and 5 persons.
Captain: Gustave Jean LEFÈVRE
Radio operator: Lucien OURY
Flight engineer: Roger KIEFFER
Route: PARIS-LYONS-MONTPELLIER-TOULOUSE

We were about to take off from Le Bourget when the tower instructed us to wait, saying that an aircraft had lost its way above the clouds and its position was not known. We therefore stopped at the beginning of the runway.

When the tower finally authorized us to take off, Paris Control had got into contact with the C-119 on 118.5 kc/s and believed it to be to the north of the airport, in good visibility above the cloud layer. Ceiling was at about 300 ft., and the cloud layer was about 1,300 ft. thick.

After take-off I also switched to 118.5 kc/s and heard the American aircraft which was flying in good visibility near the lights of Paris, but with no radio compass and completely confused, saying that he was lost, could not get his position and had fuel for only about another half hour...

The pilot's voice betrayed his anxiety and revealed the urgency of the situation. As I could make out an aircraft to my left and speak fluent English—and even American—I asked Paris Control for permission to contact the pilot. I then called the aircraft and asked it to signal me with its landing lights; but then I discovered that it was not the aircraft I had seen. I then asked him to leave his lights on and, making a wide turn, I saw a white light on the clouds about six miles away. It was the *Flying Boxcar* to whom I signalled in turn. The most difficult part was done!

Once in communication with the pilot, I immediately gave him the course to steer to get back to the north of the airport and manoeuvred myself as close as possible to him, giving him his exact position and explaining just what I was going to tell him to do in order to find the runway.

I then passed him on the weather reports, landing direction and ground pressure, all the time making him follow the shortest possible procedure. When we arrived on the ILS axis heading towards the runway, I placed myself behind him so as to check his alignment. We were still above the clouds. After passing the outer marker I told him to descend, following 150 feet behind and 65 feet above him until he disappeared from view. We reached the middle marker. I climbed back "on top" and told him to continue descending...

A few seconds later he was within sight of the ground and the next minute he told me he was on the runway and thanked me warmly (I was as moved as he). It was 23:20. I resumed contact with Paris Control and set course for Lyons.

*

The reports ends here, but Captain Lefèvre adds the following comments:

There you have the truth on this happy incident. As you see, we were extremely fortunate in finding him and making ourselves understood, as he spoke no French. The thing I regretted most was not being able to land immediately to toast our common brotherhood.

The C-119 had come from London. It was on its way to Châteauroux but had been rerouted to Orly, where it had made a baulked approach (no easy matter with a ceiling of 100 feet). His radio compass had probably got over-heated, as well as his ILS, and he was completely bewildered, not without reason... That is why I kept up a long conversation with him (with all sorts of mistakes in English) to restore his confidence.

I am telling you all this in detail because some hair-raising things have been written, such as "he plunged into the clouds with all lights burning to look for the other aircraft"... or "he dived into the cloud layer to act as guide..." You see what such statements could lead to. But I have no desire to be taken for a complete idiot!

But surely the truth is eloquent enough!

ZURICH 1956

Kloten Airport, static show: Left, a Fairchild C-119; centre, Douglas C-124; right, Tupolev Tu-104; bottom, Oerlikon surface-air missile.

Nine nations took part in the Zurich International Air Meeting of May 26th-27th at Kloten Airport and Dübendorf air base and thus marked the revival of a pre-war tradition. It was in fact in 1937 that the last of the great Zurich air displays had taken place.

The participation — and the type of participation — in the Zurich event by the United States, France, Great Britain, Italy, Switzerland, Sweden, Holland, Czechoslovakia and the Soviet Union was significant from several points of view.

• Because of the presence of aircraft and — more important — of aviation experts from behind the Iron Curtain, the Western air powers, naturally led by the U.S.A., did not content themselves with putting on show a few tired old aeroplanes that had been in squadron service for years. Instead, they presented their

The Czech Super Aero 45.

Morane 760 *Paris* jet tourer.

Piaggio P.149 trainer.

SIPA 1000 *Coccinelle* ultra-light tourer.

Friendly line-up at Kloten! *Left to right:* C-124, Tu-104, Fokker S.14, *Super Sabre*, *Sabre* F-86D, *Sabre* F-86E.

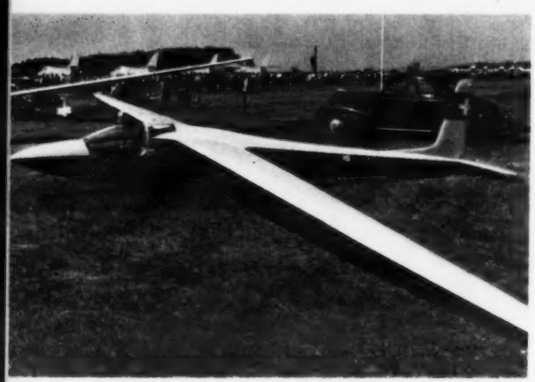
Swiss Defence Minister Chaudet (left), Swiss Air Force Chief of Staff Col.-Divisionnaire Etienne Primault (right).

Swiss industrialist (Oerlikon) Emil Bührle and Marshal Rudenko, Deputy C.-in-C. of the Soviet Air Force.

Group Captain Roy Scott, at the time British Air Attaché, Berne.

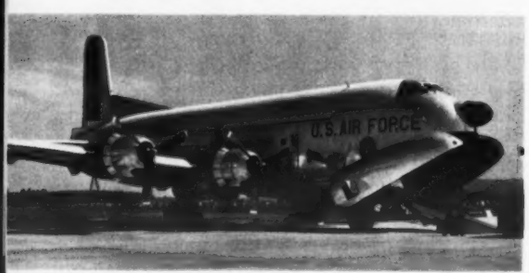
Lt.-Gen. William H. Tunner, Commanding General, U.S.A.F in Europe, and Mrs. Tunner.

Tupolev Tu-104: *left:* tail unit and main entrance; *centre:* nose, with search radar plastic dome and radio aerials; *right:* full view of the "star attraction" at Zurich.



Swiss WLM high-performance glider.

North American F-100C *Super Sabres.*



Douglas C-124 *Globemaster* heavy transport.

Boeing B-47 *Stratojet* medium bomber.

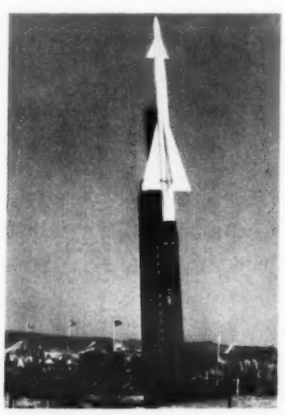
latest operational aircraft — F-100C *Super Sabres,* F-86D *Sabre* all-weather fighters, B-47 *Stratojet* bombers, *Hunter Mark VI, Valiant* medium bombers, *Mystère IV* fighters and a *Vautour* attack bomber — as well as a number of combat missiles.

• Taking advantage of the international character of the meeting, several countries used it for a sales demonstration. The French aircraft industry showed all the modern equipment it has for sale, from the *Coccinelle* ultra-light aircraft to the Morane *Paris* jet tourer and the *Caravelle* jet transport. The Czechs put on a skilful flying demonstration with three Zlin 26 *Trener* aircraft and showed a *Super Aero* 45 twin-engined executive transport.

• The Soviet Union appeared for the first time since the war at an international air event of this kind — not in a warlike guise like the other major participants but perfectly peacefully with one of its new Tupolev Tu-104 twin jet transports. The Russians invited airline executives to inspect their aircraft, pointed to the swivelling-bogie type undercarriage, mentioned jet deviators, quoted prices and handed out some sales literature (in French).

Perhaps the last aspect was the most important of the show. It no doubt is a pure coincidence that nearly twenty years ago another country took the opportunity offered by Zurich's popular fair to emerge from its isolation and seek closer contact with its neighbours.

Oerlikon Type 54 surface-air guided missiles on twin launcher.



U.S. Army *Nike* surface-air guided missile.

U.S. Army *Honest John* free artillery rocket on mobile launcher.

Six Oerlikon Type 54 missiles on special transport vehicle.

U.S.A.F. Martin *Matador* tactical missile.

French Air Force Dassault *Mystère IVA* aerobatic flight.

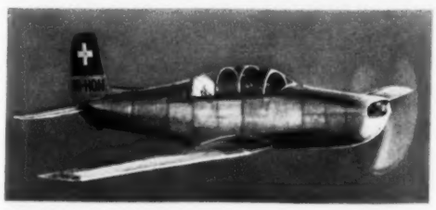
Swedish Air Force Saab J-29 aerobatic flight.

U.S.A.F. North American F-86 *Sabre* "Skyblazer" patrol.

Boeing B-47 *Stratojet* fly-past.

It was in fact at the last Zurich meeting in 1937 that the revived German aircraft industry and air force turned up with their latest prototypes and droves of brass. They used Zurich for a show of strength — a strength with which the world became woefully acquainted two years later. They invited Britons, French, Americans and Italians to their ultra-modern aircraft factories and air bases to convince them of the efficiency of their industry and the power of their growing air force.

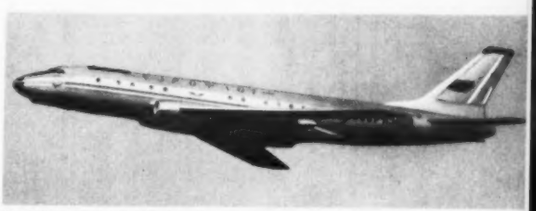
This year the Soviet Russians exhibited one of their newest civil airliners at Zurich, as a renewed hint that they want to come out of their own isolation and establish contact with the West. However, the Tupolev transport at Kloten Airport was merely the precursor of a much vaster exhibition at Tushino Airport, Moscow, to which air ministers and air force chiefs from all over the Western world were invited on June 24th and subsequent days. And by the time these lines appear, the Western aviation leaders will have returned to their desks and may now be endeavouring to assess the lessons of Tushino — initiated at Zurich — and to determine to what extent Moscow's new policy of peaceful coexistence — under the changed conditions of the atomic age — is based on strength and therefore sincere.



Swiss Pilatus P.3 trainer.

Czech aerobatic flight of Zlin 26 *Trener* aircraft.

Fouga 170 *Magister* standard jet trainer of French Air Force.



Tupolev Tu-104 in flight.

Fokker S.14 *Mach Trainer*

Sud-Ouest SO.4050 *Vautour*.

Nord 2501 *Norallas* transport.

Sud-Est SE.210 *Caravelle* twin-jet transport.

A Hawker *Hunter* of the R.A.F. aerobatic team comes in to land.

One of the two Vickers *Valiant* medium bombers (equipped for flight refuelling) simulates a landing approach. Below, the Douglas C-124.

U.S. Army *WAC Corporal* tactical guided missile.

What's in the Air?*

AIR TRANSPORTATION

● The following are some of the main points from the *I.C.A.O. report for 1955:* the introduction of turbojet transport aircraft into scheduled airline operation will mark the greatest change since the appearance of four-engined aircraft in 1939 or of the DC-3 in 1936. It is estimated that twelve such aircraft could handle the existing traffic over the North Atlantic. These aircraft are, however, inefficient for stage lengths of less than 600 miles. Assuming a load factor of 60%, the only international routes that could support the larger jet aircraft at present passenger traffic levels would be: Europe–Middle East, Europe–Far East, Europe–East and South Africa, North Atlantic, North American West Coast–Honolulu, North American East Coast–Caribbean and New York–Bermuda.

● **The Federal Republic of Germany** has become the 68th member State of the International Civil Aviation Organization.

● **Switzerland and Italy** have signed an air transport agreement covering scheduled services between Swiss airports on the one hand, and Genoa, Turin, Milan and Rome on the other. No settlement has been reached, however, on problems connected with transit traffic, but new negotiations are to be held shortly.

● **British Overseas Airways Corporation** seems likely to order a batch of American jets—probably Boeing 707s. The flying equipment committee set up in May has held its first meetings, and it is understood that the Government may withdraw its opposition to such a proposal.

● **Sabena** will operate eight inclusive tours to Russia in collaboration with Aeroflot between the end of June and the middle of August. The first trip will start from the United States and will take 18 days, of which eight will be spent in the Soviet Union. From Prague onwards tourists will travel in Aeroflot aircraft.

* Extracts from *Interavia Air Letter*, daily international news digest, in English, French and German. All rights reserved.

The CF-100 twin-jet all-weather fighter of A.V. Roe (Canada) Ltd.

Detonation of a small version of a future big H-bomb at Eniwetok Atoll on May 5th. Picture was taken from a distance of 12 miles.

● **Jet fighter pilots** in the Air Force and Navy will probably be the best jet transport pilots, says Dr. Neil D. Warren, Chairman of the Psychology Department of the University of Southern California. Dr. Warren bases his belief on the fact that the Lockheed T-33 jet trainer is an excellent introduction to the B-47 *Stratojet* and that this aircraft and others like it will serve as trainers for future transport pilots. A jet pilot must have confidence in his ability to fly the aircraft and must be carefully selected, well-trained and mentally and physically fit. Military jet pilots fill these requirements admirably.

● **Australia's airlines** carried well over 2,000,000 passengers on domestic services and 59,000 on Australian international services in 1955. Total traffic volume (passengers, freight and mail) increased by one twelfth over the previous year. During the past four and a half years more than 8,000,000 persons have flown on Australian airlines without a single fatal accident.

● **The Soviet Government** is said to have offered the Tupolev Tu-104 medium-stage jet transport for sale to a number of Western airlines during the Zurich Air Show on May 26th and 27th. Price asked is given by the London "Sunday Times" as £425,000 ($1,190,000), and delivery date as 1958.—By comparison, the future *Comet IV* will cost more than £1,000,000 ($2,800,000).

INDUSTRY

● **Aeronutronic Systems Inc.** is a new subsidiary of Ford Motor Company, as briefly reported in *Interavia* June issue, for research in the fields of guided missiles and possibly space travel. The nucleus of the new company is a group of scientists and engineers recently formed in Los Angeles under the name of Systems Research Corp. Head of the group is Dr. Ernst Krause, who resigned not long ago as head of Lockheed Aircraft's Missile Systems Division, taking with him other leading scientists. Dr. Krause will be Vice-President in Charge of Research and Development of Aeronutronic Systems. President is Gerald J. Lynch, formerly Director of Ford Motor's Office of Defense Products and Governmental Relations.

● **The Convair Division** of General Dynamics Corp. has delivered the first production F-102A delta-wing interceptor to the U.S. Air Force. First unit to fly the type is the 327th Fighter Interceptor Squadron at George Air Force Base, Victorville, California.

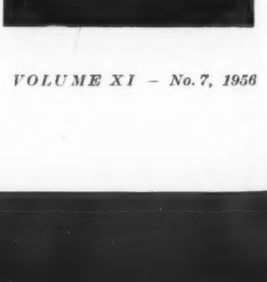
● **Donald W. Douglas** founder and President of Douglas Aircraft Company, has been chosen to receive the 1956 Elmer A. Sperry Award given for "distinguished engineering contribution". The award is made every year jointly by the American Society of Mechanical Engineers, American Institute of Electrical Engineers, Society of Automotive Engineers and the Society of Naval Architects and Marine Engineers.

● **Kawasaki Aircraft Co.,** which is now manufacturing the Lockheed T-33A under licence, is reported to be interested in building the Lockheed F-104A *Starfighter*. Another rival for the licence

Maintenance of a Canadair *Sabre* at a Royal Canadian Air Force station near Metz, France. The whole rear fuselage including tail can be drawn back over the jet pipe to give easy access to the engine.

L. H. Bedford, Chief Engineer of the Guided Weapons Division of the English Electric Company and leading radar expert, has been made a Commander of the Order of the British Empire.

General Guillaume L. Chassin has been appointed Coordinator of Air Defence in Central Europe (Fontainebleau).



Final assembly of the F-100 *Super Sabre* at North American Aviation Inc.'s Los Angeles plant.

D. Napier and Son Ltd.'s rotor test bench for helicopter engines. The facility was designed primarily for tests on the Napier *Oryx* turbo gas generator.

is Mitsubishi Heavy Industries, which originally wanted to build the North American F-100 *Super Sabre*. The Company is now urging the Japanese Government to acquire the F-104A licence direct and not to let it go to a private company (Kawasaki). This would enable Mitsubishi to participate in the manufacture of the F-104A without a licence relationship with Lockheed.

● **Société Nationale d'Etude et de Construction de Moteurs d'Aviation** and Bureau Technique Zborowski have concluded an agreement under which S.N.E.C.M.A. acquires patent rights for the coleopter configuration. The agreement applies to all countries in Europe and supplements an earlier accord reached in 1952 giving S.N.E.C.M.A. an option on the patents.

● **Radio Switzerland,** which has been operating flight control services throughout Switzerland since 1931 on behalf of the Federal Air Office and the Cantons of Zurich and Geneva, reveals in its annual report for 1955 that air traffic control projects estimated to require expenditures of more than 10,000,000 francs are now being worked out. The Zurich-Kloten and Geneva-Cointrin control towers in 1955 recorded jointly 125,620 aircraft movements, making an average of 350 a day. Over 10,000 aircraft availed themselves of the control towers' radar and ILS facilities.—Personnel employed rose from 15 specialists in 1931 to 225 in 1955 (plus 270 persons in the company's commercial services).

● **Experiments with radio-sondes** have been taking place at the Aerological Station, Payerne, Switzerland, under the auspices of the World Meteorological Organization, for the purpose of comparing radio-sondes used in different countries and achieving standardization. A total of 14 different types of radio-sonde have been demonstrated. Delegations were sent from Austria, Belgium, Egypt, Finland, France, the German Federal Republic and the German Democratic Republic, India, Japan, the Netherlands, Poland, the Soviet Union, Sweden, Switzerland, the United Kingdom, the United States and Yugoslavia.

SERVICE AVIATION

● **The Indian Air Force's** procurement programme appears to be far from settled. Reports from Bombay that Prof. Kurt Tank is to design and test "the first Indian fighter" for Hindustan Aircraft Ltd., of Bangalore—an arrangement which would suggest abandonment of plans for building the Folland *Gnat* under licence—have been denied in an official statement by Folland Aircraft Ltd.: "As far as the company's negotiations with India, which have been going on for nearly two years, are concerned, finality has nearly been reached. The company is in fact expecting the arrival in England of Indian Government officials to sign the contract for the purchase of *Gnats* and their manufacture by Hindustan Aircraft, Bangalore."

Pakistan International Airlines has ordered three Vickers *Viscount 810s*. Left to right: R. P. Yapp, Director of Vickers-Armstrongs Ltd.; A. Lawrence Cooper, General Manager, Contracts; M. A. Ispahani, Chairman of P.I.A.; Hafeez Ahmed, Financial Adviser to the Ministry of Defence, Pakistan.

Varig of Brazil is the first South American airline to have ordered two Lockheed 1649A *Super Constellations*. Rubem Berta, Varig's President (left) and Wayne Cannon, Lockheed's South American Sales Manager, inspecting the model of the latest *Super Constellation* version.

The new management of United Aircraft Corporation. Left to right: H. Mansfield Horner, Chairman of the Board and successor to the late Frederick B. Rentschler; Leonard S. Hobbs, Vice-Chairman; William P. Gwinn, President and Chief Administrative Officer; Wright A. Parkins, Vice-President and General Manager of the Pratt & Whitney Aircraft Division; Arthur E. Smith, Engineering Manager of the Pratt & Whitney Aircraft Division.

Kaman HOK-1 with skid landing gear.

Grumman F9F-8T *Cougar* jet trainer.

● **The Japanese Defence Board** has placed provisional orders with Shin Mitsubishi Heavy Industries for 110 F-86F *Sabre* jets and with Kawasaki Aircraft Co. for 83 T-33A jet trainers. The aircraft are expected to be delivered by the end of June 1958. The orders are the result of the second jet aircraft production agreement signed between the Governments of Japan and the United States last April. Discussions are already believed to be in progress on the third and fourth jet aircraft production programmes. Under the third programme, Japan reportedly will manufacture 200 F-86F *Sabres* and 180 T-33As, while under the fourth programme an additional 200 F-86Fs are to be produced.

● **"SMART"**, the Supersonic Military Air Research Track on Hurricane Mesa, west of Zion National Park, California, has been shown to the press for the first time. Object of the 12,000 feet long track and its rocket-propelled sleds is to perfect ways for crews of supersonic aircraft to survive emergency bail-outs while flying high and fast. Performance of the $ 2,000,000 facility has been a strict secret. However, the sleds are propelled down the track at speeds which designers hope will reach more than 1,500 m.p.h. The facility was built by Coleman Engineering Co., Los Angeles, and turned over to the U.S. Government last summer.

AIRCRAFT AND ENGINES

● The *Convertawings Quadrotor Model A* helicopter is undergoing flight tests at Amityville, Long Island. It is the result of extensive research work in the company's programme to design and develop a large transport type helicopter for the medium and short haul market.

● The *BB-152 jet commercial transport* under development for the East German Lufthansa at VEB-Industriewerk, Dresden, has a slightly swept shoulder-level wing (angle of sweep 20°) and sharply swept elevator and rudder units, according to unconfirmed reports. The four jet engines are suspended two by two on pylons underneath the wing, at about 25% of the span. According to other reports, only two jets are to be fitted initially, in a similar type of suspension.

● The *Turboméca Baston* turboprop delivers a power of 650 h.p. for a weight of 595 lbs. and is to be fitted, for example, in later versions of the S.N.C.A. du Sud-Est *Fonceur*.

● The following design data for the projected *Douglas DC-9* medium-stage jet airliner have been released: gross weight 134,000 lbs., max. landing weight 106,000 lbs., payload (space-limited) 20,200 lbs. in the first-class layout for 66 passengers and 23,840 lbs. in the 94-seat tourist version; cruising speed roughly 480 knots; range with max. payload 1,770 nautical miles (first-class version) or 1,510 nautical miles (tourist-class version). Span 112.76 ft., length 118.75 ft., wing area 1,790.6 sq.ft.

Aerfer *Sagittario II* light-weight fighter.

● *Boeing Airplane Co.* is also working on a medium-haul jet commercial transport. Several projects are under consideration, including both two and four-engine designs. Gross weights range from roughly 60,000 to 140,000 lbs.

● A new trainer being developed for the U.S. Air Force by Northrop Aircraft Inc. is expected to be powered by the General Electric J-85 turbojet with afterburner. This engine reportedly delivers a thrust of 2,500 lbs. without reheat.

● The *Leduc 022* experimental ramjet aircraft has been completed at the Argenteuil plant and taken by road to Istres. First flight is scheduled for the end of September.

● The *Hispano Suiza R.800* turbojet, which recently completed a certification test for a thrust of 3,130 lbs., has just successfully made a test at a thrust of above 3,310 lbs. Total dry weight remains at 672 lbs.

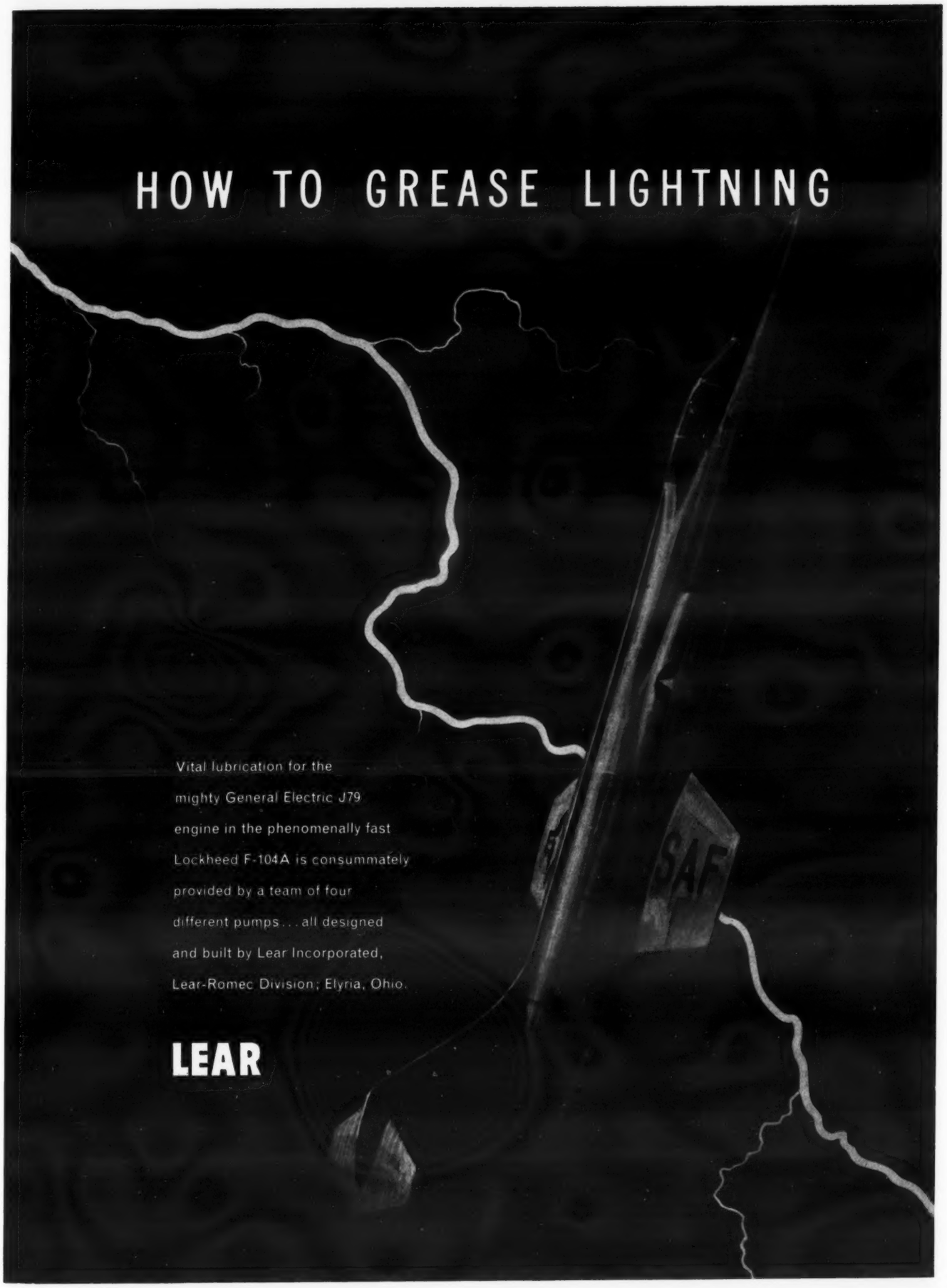
● *Vertiplane* is the designation of a VTOL aircraft which will be built by Ryan Aeronautical Co. for the U.S. Army. It resembles a conventional light aircraft and is best adapted to medium speed liaison, light passenger and cargo transportation. The slipstream from the two propellers is deflected through approximately 90° by an arrangement of double flaps, to achieve vertical take-off and landing. The *Vertiplane* is claimed to be capable of the same flight manœuvres now associated with helicopters, yet will possess performance exceeding rotary-winged aircraft in speed, range, altitude and endurance.

● North American Aviation and the U.S. Air Force have verified that the company is developing a manned aircraft for flight investigations at extreme altitudes. Known as the X-15, it is expected to attain an altitude of 100 miles, and will probably not be completed and ready for flight until 1957.

● Convair has announced revised data for the *Skylark* medium-stage commercial transport. Weight empty is now given as 78,100 lbs., max. take-off weight as 173,500 lbs., and max. landing weight as 120,000 lbs.—There is also talk of attaching the nacelles for the four General Electric CJ-805 jets direct to the wing underside, instead of fitting them to pylons underneath the wing.

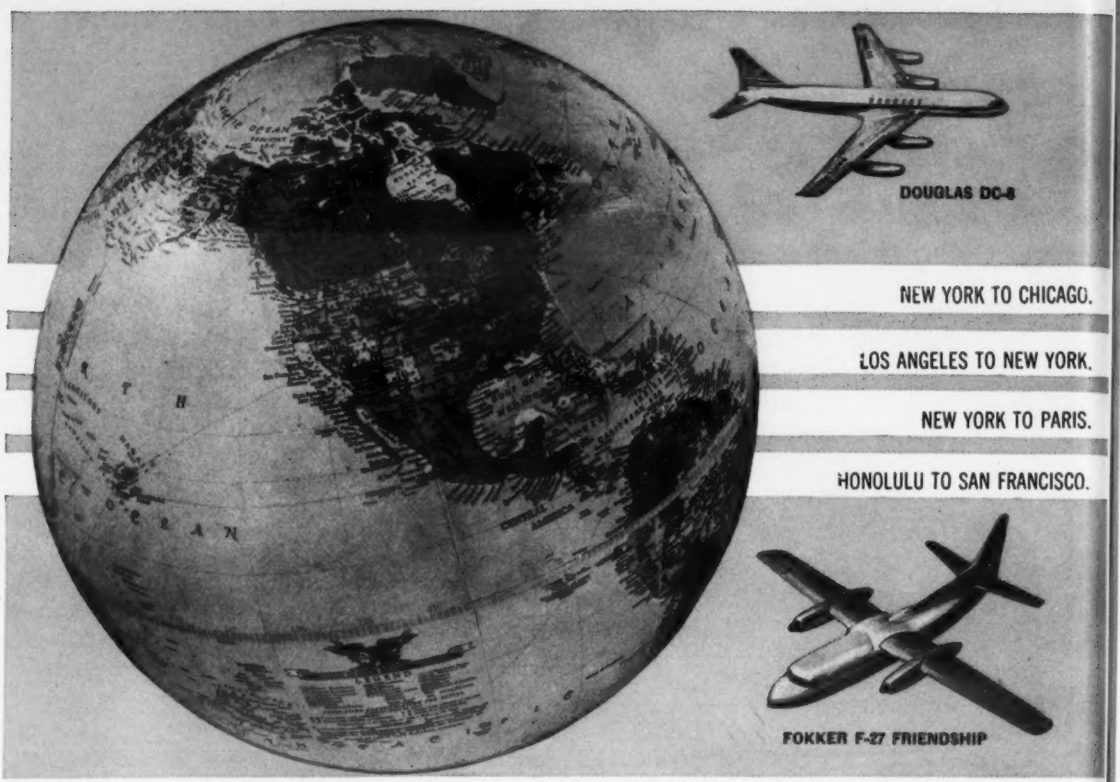
The giant Douglas C-133A transport took off on a recent test flight with a gross weight of 116 tons.

HOW TO GREASE LIGHTNING



Vital lubrication for the mighty General Electric J79 engine in the phenomenally fast Lockheed F-104A is consummately provided by a team of four different pumps... all designed and built by Lear Incorporated, Lear-Romec Division, Elyria, Ohio.

LEAR



Jet airliners shrink globe . . .

When you and your family board these new jet airliners, you'll be stepping into a completely new era of transportation designed to get you where you are going faster, more comfortably and more dependably. To appreciate the progress that has been made, following are some exclusive jet problems that had to be licked and some original answers to those problems worked out by Bendix Aviation Corporation.

For example, the starting, generating and ignition systems used on reciprocating engines were not applicable on jets. One of our new Bendix jet starters, small enough to put in a breadbox, produces 450 h.p. to crank a giant jet engine 1800 r.p.m. in three and a half seconds.

Igniting a jet is like lighting a match in a tornado. An ordinary spark has no chance. New Bendix jet ignition produces a super spark that fires jet engines immediately.

Jets are fuel hogs with very sensitive digestive systems. Not too much, not too little—the mixture's got to be just right. Speed, temperature and altitude affect this mixture. Thus, fuel-air proportions must be changed rapidly and automatically. New Bendix* fuel-metering and engine control systems are precise and automatic, take another tough problem off the crew's backs.

Jet speeds necessitate more accurate navigation and piloting. Here several exclusive Bendix devices team up for greater precision: The

ADVANTAGES OF THE JET AGE WILL BE JET PROBLEMS—HAS

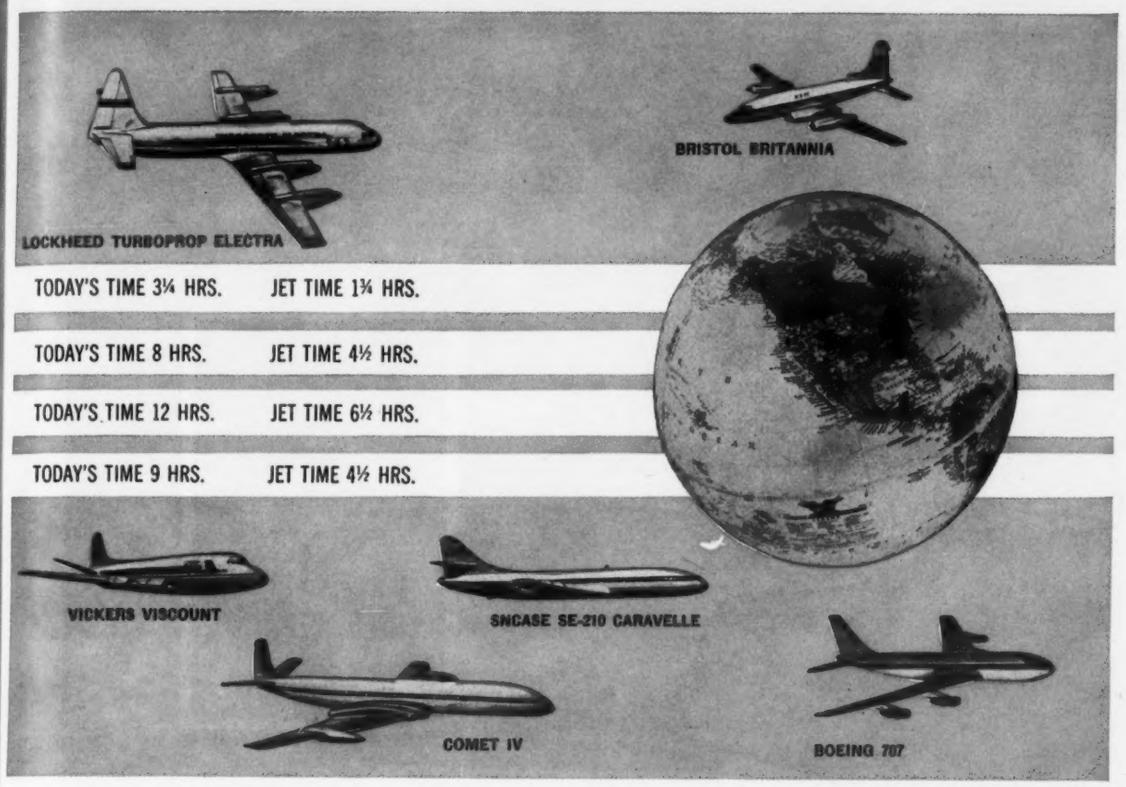
COMPLETE TRANSISTORIZED NAVIGATION AND CONTROL SYSTEM
Includes automatic pilot capable of automatic landing approaches; Flight Director systems; heading reference systems.

AIRBORNE RADAR SYSTEM
Sees storms 150 miles away and shows how to avoid them for smoother ride.

RADIO COMMUNICATION SYSTEM
Including receivers, transmitters, flush antennae, radio compass, radio magnetic indicators, marker receivers, glide slope receivers, VOR-localizer receivers, Omni-mag indicators, cockpit loud speaker, distance measuring equipment, transponder beacon and selective calling, passenger address and transistorized interphone systems.

LIQUID OXYGEN SYSTEM
Automatic high-altitude oxygen system for passengers plus flight crew oxygen system.

SPECIAL INSTRUMENTS
To measure Mach airspeed and fuel flow; accelerometers; specially lighted turn-and-bank and rate-of-climb indicators.


LOCKHEED TURBOPROP ELECTRA
BRISTOL BRITANNIA
TODAY'S TIME 3¼ HRS. JET TIME 1¾ HRS.
TODAY'S TIME 8 HRS. JET TIME 4½ HRS.
TODAY'S TIME 12 HRS. JET TIME 6½ HRS.
TODAY'S TIME 9 HRS. JET TIME 4½ HRS.
VICKERS VISCOUNT
SNCASE SE-210 CARAVELLE
COMET IV
BOEING 707

. . will cut travel time in half!

YOURS SOONER BECAUSE BENDIX ANTICIPATED THESE DEVICES READY NOW

COMPLETE LANDING GEAR
Including wheels, brakes, shock absorbers and "Cerametalix" brake lining—our special friction material developed for stopping jets.

TURBINE STARTERS
Originated by Bendix to solve the problem of starting jet engines.

AC GENERATING SYSTEM
Including fault-detecting and regulating devices and inverters.

RELIABLE, RUGGEDIZED ELECTRON TUBES

JET IGNITION SYSTEM
Provides extra hot spark for starting and high altitudes.

FUEL-METERING AND ENGINE CONTROL SYSTEM
Provides proper air-fuel mixture at all speeds, temperatures and altitudes.

HYDRAULIC CONTROLS
For raising and lowering landing gear, applying boost power to control surfaces. Includes servo-valves, accumulators, positioning actuators, pressure reducers, relief valves, hand pumps, flow dividers and cylinders.

Polar Path* compass, which made polar navigation practical and which is equally accurate anywhere; the Flight Director, a simplified navigation system in which two instruments replace many; and the first completely transistorized automatic pilot which will not only fly jets with more exactness than human pilots but automatically bring them in for pinpoint landing approaches.

Ordinary brakes and lining can't stop the fast, heavier jets. New Bendix* jet airplane brakes and our special Cerametalix* friction material licked the stopping problem. New Bendix* landing gear and shock absorbers set them down softly.

Airborne radar to spot storms ahead, surveillance radar to help control airport traffic, G. C. A. radar for bad weather landings, a complete line of ground and air radio communications systems and automatic liquid oxygen systems are some of the other proven devices we have ready now for passenger jets.

This is probably the most complete package of equipment ever offered a new industry by one supplier.

Bendix has hundreds of products for other fields, also. Write for "Bendix and Your Business".

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New G-E Long-Range Radar Gives Full Control Of All Air Traffic Along World's Busiest Airways

Now in operation at Idlewild Airport, the FPS-8 type radar " monitors " all arrivals and departures at the six major New York airports and all " through " non-landing traffic, and virtually eliminates " stacking " even in IFR weather.

Covers an area of more than 30,000 sq. miles. The extremely complex air traffic problem in the New York City area, considered one of the busiest air traffic areas in the world, is being controlled through the installation at Idlewild International Airport of the new General Electric FPS-8 type Air Traffic Control Radar equipment.

This long-range radar gives complete control of all " in and out " traffic at the six major New York area airports, as well as aircraft passing through but not landing, even in very bad weather. With the entire area under a single radar control, the relatively limited airspace is utilized to the maximum and " stacking " and waiting for permission to land is virtually eliminated at any of these New York airports.

With this General Electric radar, the ten minute separation between aircraft, required by Instrument Flight Rules, can be reduced substantially until no more than five miles may be required in some instances. Thus, in bad weather, the G-E FPS-8 type radar can expedite aircraft arrivals at the six terminals to the point that the acceptance rate of air traffic entering a New York airport may be increased to the physical acceptance legal limits of the airfield itself. Departures also are expedited, as the FPS-8, working with the smaller Control Tower radars at each airport, monitors each aircraft leaving the metropolitan airports until it has reached its assigned cruising altitude. This permits elimination of the 10-minute longitudinal air-space separation here, also. Long-range air traffic control is only one of the many new developments made possible by G-E research and electronic engineering skill. See your nearest G-E representative or write Electronics, *International General Electric Co., 150 East 42nd St., New York 17, N.Y., U.S.A.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

—U.S.A.—

Some Home Truths on Aircraft Instruments

by Jacques LECARME,
Chief Test Pilot, S.N.C.A. du Sud-Est, Marseilles-Marignane

" You, who are a scholar, tell me how you can distinguish your left hand from your right..."

In the following lines the writer puts forward some very definite and doubtless biased opinions on a subject of endless controversies between the pilot on the one hand and the aviation authorities, military and commercial operators, instrument and aircraft manufacturers on the other, namely aircraft instruments. He thus vents the accumulated frustrations of twenty-five years of unnecessary fatigue in flight and begs that no-one will take his frankness amiss...

Why do we have instruments in aircraft ?

For two reasons that are of no particular credit to the human race.

1. *The designer is never quite sure that his " contraption " will work.*

Hence it must be monitored. This is a grievous admission of a basic weakness in the component in question. Surely the money and extra weight involved in watching for failure could better be employed to reduce the likelihood of breakdown to infinitesimal proportions. Strangely enough, this idea has never been given serious consideration.

Some examples : If an aircraft can penetrate the sound " wall " without abnormal behaviour, a Machmeter is quite unnecessary. If, because of its design or its regulation system, an engine cannot reach temperatures likely to imperil its working life, there is no need for thermometers In any case, it is not an extra thermo-couple here or there that will prevent the engine from overheating.

2. *Man is a " visual " animal...*

... and when he can no longer see, his eyes must be replaced by instruments. But no instrument can yet replace his brain, so that all instrument readings still have to be interpreted by this highly unpredictable organ, whose operation cannot be classified under any system of standards.

This suggests certain very simple rules, hitherto scandalously ignored, for the presentation, number and type of the flight instruments unfortunately needed in an aircraft.

What does the pilot want ?

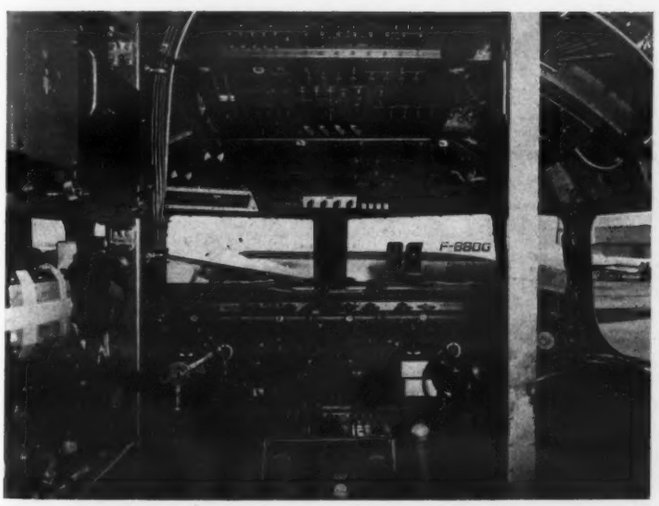
He does not want to see everything and know everything. But he is too often given the elements of a problem as the gifted mathematician or engineer sees it from his comfortable vantage point on the ground. After due and careful study, the latter will give the pilot merely the basic elements of the equations relating to his movements, such as the geographical coordinates of his position, his pressure altitude, magnetic heading, his three angular velocities of rotation, plus a number of linear acccelerations and, if he is especially generous, a few time derivations of the above values.

All this is fine for the task of reconstructing trajectories on the ground from recorded data and is essential at flight test establishments. But one flight takes *weeks* of calculations. And these scientific data are of scant assistance to the pilot flying under Instrument Flight Rules, who asks *two vital questions :*

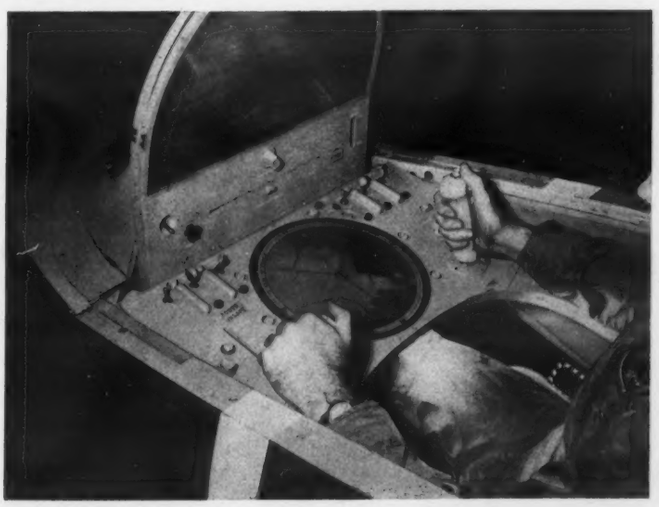
1. *Where am I ?*
2. *What shall I do now ?*

To ensure a quick and correct response the greatest possible use must be made of the standard connections between the senses and the brain and memory cells, avoiding all processes involving acquired habits. *In short, the pilot must be able to see clearly.*

Today: the over-loaded instrument panel of a four-engined transport (Douglas DC-6).



Tomorrow: two radar screens replace the conventional aircraft instruments (Douglas television cockpit).



The instrument problem

New instruments are constantly being added to cockpit panels, but none are ever removed. — Even pilots are always talking about the extra instrument they need to solve one more problem, but never mention those they could do without.

Example : To answer the question *" What is my position, projected on the ground, 18 minutes after passing beacon FOQ ? "* the following improbable-sounding list of operations has to be completed under present time-honoured procedures :

1. read off the indicated barometric altitude and correct it from QNH (ground pressure) ;
2. read off ambient temperature and correct if from the indicated air speed or Mach number ;
3. use calculator to determine cruising altitude density from two above values ;
4. this, combined with the indicated air speed and with allowance for Mach number, gives corrected speed ;
5. estimate wind direction and force or measure them on drift meter ;
6. read off magnetic heading, corrected from the deviation table ;
7. these give, finally, ground speed in magnitude and direction ;
8. integrate the latter as a function of time... *en bloc* or in stages if it has varied ;
9. the pilot now has his estimated position, with its zone of uncertainty (margin of error).

The pilot thus has to consult at least *five* instruments and to estimate a number of other values which some would like to be able to measure exactly.

What does the pilot want to see on his instruments ?

Vectorial instruments (so called for the sake of simplicity).

It is more important to know the *direction* in which a correction must be made than the *amount of error*. Other requirements are as follows :

1. instruments should be as few as possible in number.

2. what the pilot wants is not the elements of a calculation, but final values from which he can steer his aircraft.

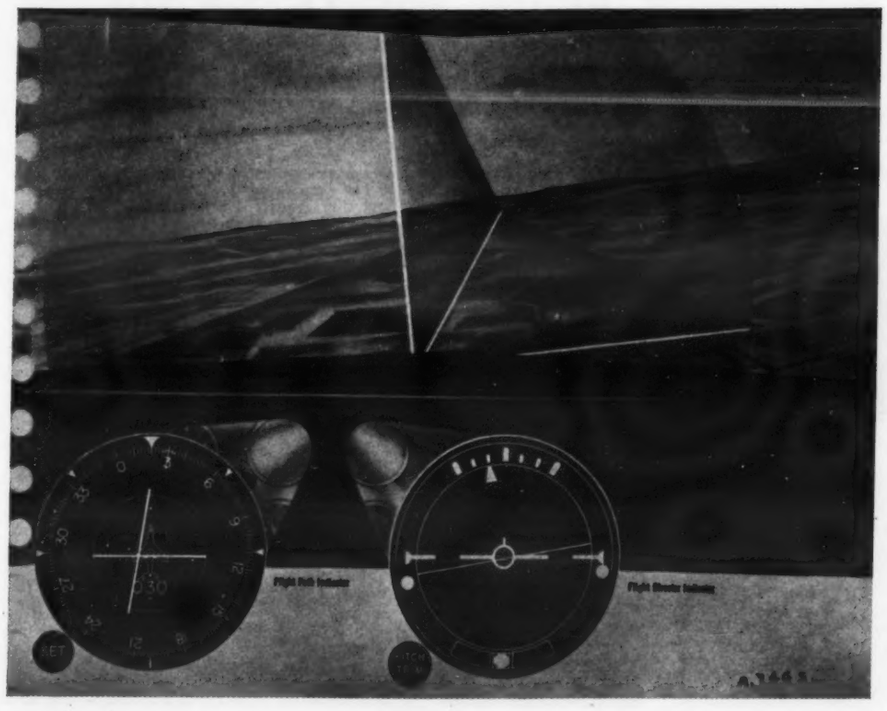
3. he wants to see on the instruments what he would see out of the window, so that he does not have to use different faculties, and thus in a sense change personalities, in order to understand their indications.

4. he *first* wants to know what he has to do immediately or in the near future, i.e., the *future.*

5. then, when he has a bit more time, he is interested in the whys and wherefores, i.e., the *past.*

6. at more than 45° roll in relation to the ground, the ground expert's up and down, right and left, no longer mean anything to the pilot. Hence the instruments must do his thinking for him and transform the ground expert's orders into : go to your right (starboard), go to your left (port), climb or descend, regardless of the aircraft's attitude in relation to the ground.

The instrument should picture what actually lies ahead of the aircraft's windshield : Bendix course indicator (left) and Flight Director (right).



The two systems of reference

Here mention should be made of some of the points in the timeless controversy between the ground expert, the " absolutist ", who measures all things in relation to the earth, and the pilot, an enforced " relativist ", who is bound to his aircraft's axes of reference, since he is *inside* it—and firmly held in place by his safety belt.

These two systems of reference and the instruments based on them can be classified as follows :

SYSTEM A — THE EARTH

The aircraft's position is given in relation to the ground. The zero reference on the instrument is fixed, and the pointer indicating the aircraft's position for the value in question is mobile.

The instrument tells the pilot where he is, but not what he must do. He has to know by heart, *for every single case,* the direction in which to manoeuvre in order to return the pointer to zero.

I regret to say that some very well-established instruments fall into this category, such as :

— the directional gyro ;
— the turn-and-bank indicator ;
— the VOR ;
— the rate-of-climb indicator.

These are excellent for the navigator. But their designers have forgotten that the pilot is *in the centre* of a sphere of reference, which is shown him on the instrument *as seen from the ground and from outside,* hence indications with the reverse directions (directional gyro).

SYSTEM B — THE AIRCRAFT

The position of the ground is indicated in relation to the instrument, whose zero represents the aircraft. In order to return the indicator to zero, the aircraft must thus be manoeuvred in the direction of the deflection.

This gesture, about which there has often been argument, is the one I use when I move my right hand to pick up my pen to the right of me, i.e., to eliminate the distance between my hand and the pen, or when I turn my head to follow something in motion.

Examples of instruments based on this reference system

— the gun sight ;
— the Zero Reader ;

The pilot should be given not the factors in an equation, but the final result, in the form of " flyable " values. The three main instruments in Sperry's Integrated Instrument System provide (left to right) bearing, heading and desired course (Gyrosyn compass indicator C-6), vertical meridian, roll position, flight director cross pointers and fixed horizon reference (horizon flight director HZ-1), and window for course, pointers for position relative to glide slope and localizer beams (pictorial deviation indicator R-1).

— the radio compass ;
— the ILS approach instruments and Sperry or Bendix Flight Director.

*

Ground experts in all countries periodically question the value of the second system. On each occasion the same arguments are produced (I experienced them in France in 1937, and there is at present a similar crisis in the United States, Britain and again France), namely that instruments based on the first system are : a) easier to learn (yes, on the Link trainer) ; b) easier to understand (yes, in a non-accelerated field, a good armchair, by a pilot with no other preoccupations and held by gravity to the earth's co-ordinates) ; c) logical (by what logic ?).

In practice, it is true, both sorts of instrument are used side by side unconsciously, often through conditioned reflexes. *But in my view, system B is necessary for instantaneous action and in emergencies.*

In such cases the pilot has not time to convert co-ordinates in his head in order to discover in what direction he must act. If his angle is more than 45° he will make a mistake in every second case, a point frequently overlooked by the ground expert and the commercial operator, who rarely find themselves in such a situation. But when it happens in flight, things are not going so well.

To the question, " What must I do, push or pull, turn left or right ? " the instrument replies only after a brief trial, often unconscious, but taking up time. *Too late !*

Graduated scale instruments

A value is measured in figures. Frequently a single figure suffices to indicate what must be done. On the subject of instruments with figure indications, I suggest the following principles :

1. There should be as few as possible.

2. The required value should be provided direct, and not merely the means of calculating it. The actual calculation could be done automatically by a computer between the detector and the indicator. For example, what the pilot wants to know is his *true speed* (for solving navigation problems and estimating power reserve) and *angle of incidence* (for estimating his lift reserve), and not Mach number or indicated air speed, which can be translated into useful values only by allowing for altitude, aircraft weight and load factor.

3. Indications must be capable of being read rapidly and without error. The simplest method is that of the counter.

*

Despite its obviousness, the last point is the most difficult to get over. It is easy to read any graduated scale on the ground. But reading it in a hurry with a brief glance, in a badly-lit corner of the instrument panel at night during an ILS approach for example is another matter. Try using a slide rule while driving a car, even in daylight ...

The pilot's accommodation faculty is often reduced by the fact that his pupil is automatically dilated or contracted by outside lighting conditions.

When flying at night the pupil is dilated, and figures are difficult to decipher when illuminated by only a weak white light (hence the use of intense red lighting in some cases).

During day flight at high altitude the pupil is contracted by the dazzling light diffused from the lower layers of the atmosphere, and the instrument panel is no longer lit by the sky above. The pilot must shade his eyes in order to dilate his pupils and read his instruments, or take off his sunglasses, which wastes time. At about 65,000 ft. the full lighting must be switched on.

The following suggestions are based on practical experience, not on " logic ".

1. Instruments should have circular scales. When there is no time to *read* a figure, it is easier to grasp an angular position than a needle moving over a rectilinear scale.

2. The decimal system of marking should be used throughout for the figures marked (not 2 by 2, or 2.5 by 2.5).

3. Graduation marks should be of different lengths at both ends, not halted at marked circles (because of the eye's astigmatism ; see drawing).

4. There should be a *single*, long pointer. Higher figures should be shown in a window to the left of the axis and should be read from left to right, as on the ground. Magnitude should increase in clockwise direction (reflex conditioned by watch).

5. The pointer should not hide the figures (childish, but needs to be recalled).

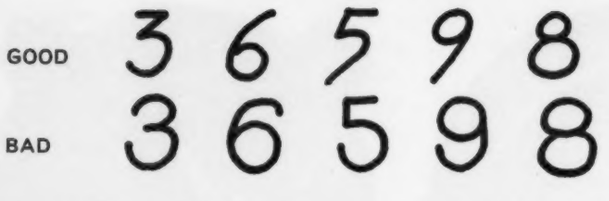
6. Figures should be drawn in such a way as to avoid confusion, not so as to look beautiful.

Units

A whole chapter could also be written on the subject of units of measure, since pilots have successfully been transformed into rapid, if not always accurate, " conversion tables ".

As our counting system is based on 10, the average European has little or no training in juggling with pounds and ounces, feet and inches, etc. For some years past our good old metric system, bequeathed to us by the French Revolution, has been treated like an outcast, and only the Russians and Chinese still believe in it.

In short, our present instruments are graduated in an incoherent selection of metric, British, American and even nautical measures. Not only does this jumble please none of the countries concerned, but it is



For graduated scale instruments and counter windows, figures should be clearly distinguishable from one another, even from a certain distance. No attempt should therefore be made at calligraphy.

Graduated scale instruments should have curved scales and long slender pointers; figures should be marked according to the decimal system, strokes should be of differing lengths and there should be no circular lines.

responsible for not a few crashes due to calculation errors.

Conclusions (admittedly biased)

1. The present standard instrument panel should be modified.

2. The number of instruments should be drastically reduced.

3. Instruments based on ground co-ordinates should be left to the navigator. The pilot's instrument panel should contain only instruments based on aircraft co-ordinates.

4. Operators should sacrifice their pride in " company " instrument panels and forget the argument " I have a stock of such-and-such an instrument in store ".

5. Positive proposals are needed, not arbitrary prohibitions.

Proposals for the future

Some day the instrument panel can finally be dispensed with, when the pilot has the following *visual indications :*

A. VECTORIAL VALUES

1. Vertical projection on his windshield of the ground in front of him with its markings, obstructions, the runway he is looking for, or the aircraft he is pursuing.

2. Horizontal projection of the same objects on an azimuth and distance radar screen.

3. A route recorder, as an aid to memory, on the radar screen.

B. FIGURE VALUES need then merely be projected on the two above-mentioned screens.

4. *Angle of attack and true speed*, the only two values of interest to the pilot, since they give his lift reserve on the one hand and the kinetic energy and change in position on the other.

5. A calculator indicating the *time* and *distance* the aircraft can still fly at its existing output and fuel reserves. This would remove the need for check instruments for engines and fuel in the pilot's panel.

6. *Barometric pressure* as the sole altitude value needed to maintain constant pressure separation.

The whole should be in a coherent system of measures.

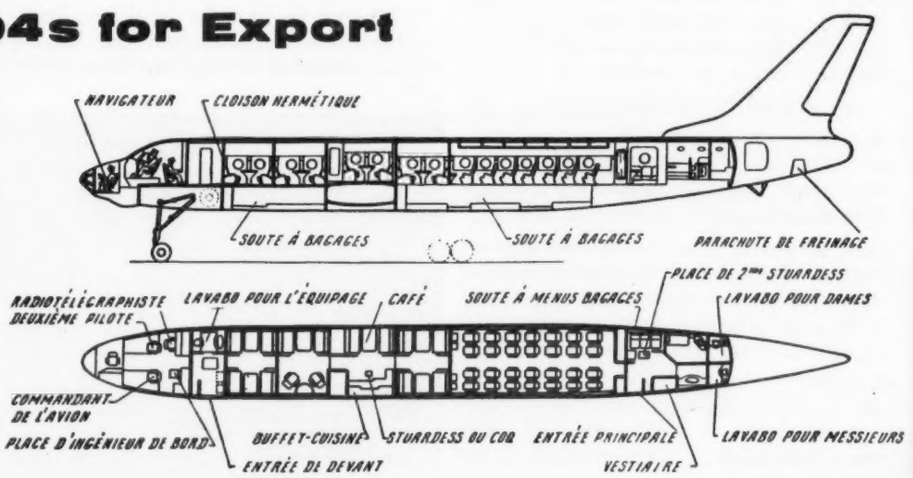
*

The pilot of the future will thus look back with amusement on the days when his colleagues insisted on knowing all the coefficients of their equations but were content with guessing their solutions.

Tu-104s for Export

It has been confirmed from several quarters that the Soviet Government has offered a number of airlines the Tupolev Tu-104 medium-stage jet transport for sale in two different versions : 1. a luxury layout for 50 passengers ; 2. a tourist version for 70 to 80 passengers. The following technical details of the two versions are announced by Russian sources.

The luxury version is designed for a payload of 11,400 to 13,200 lbs., the tourist layout for 15,400 to 16,500 lbs. The two capacious cargo holds underneath the cabin floor (fore and aft of the straight-through wing box spar) carry up to 5,500 lbs. of baggage. As the accompanying drawing shows, the fuselage is divided into an unusually large number of compartments. From front to rear: navigator's post with fully transparent nose ; flight deck for two pilots, a radio operator and a flight engineer (the two latter have backward-facing seats) ; forward vestibule with doors to flight deck and crew's toilet ; lounge with four double chairs and two dining tables ; lounge with two double chairs, a table, buffet and galley (this compartment is directly above the wing and is slightly higher than the rest of the cabin) ; lounge with four double chairs and two dining tables ; main cabin with 28 seats (four abreast) and central



aisle ; rear vestibule with wardrobe and racks for hand baggage, washrooms and ladies' and gentlemen's toilets.

The whole fuselage interior, including flight deck and cargo compartments, is pressurized during flight. Differential pressure can be adjusted between 6.4 and 8.1 lbs./sq.in., so that the pressure inside the cabin corresponds to an altitude of 7,900 to 9,850 ft. for flight at 33,000 to 40,000 ft. The forward vestibule (for the crew) and the forward lounge are separated by a pressure tight door. A brake parachute is carried in the rear fuselage, behind the retractable tail skid.—To facilitate parking manoeuvres in small space the rear double wheels in each four-wheel main undercarriage unit are swivelling.

Performance (both versions) : max. speed 620 m.p.h. ; cruising speed 500 to 560 m.p.h. ; max. range 2,800 to 3,100 miles ; cruising altitude 33,000 to 40,000 ft. ; take-off run 4,600 to 5,260 ft. ; landing run 3,620 to 3,950 ft. Price of the Tu-104 is given by British sources as £145,000 ($1,200,000).

The Importance of Terminal Air Surveillance Radar

By Spencer Ross, International General Electric Company, New York.

Spencer Ross, the author, obtained his Electrical Engineering degree from Rutgers University in 1944. Prior to his association with International General Electric Company he was with the International Telephone and Telegraph Corporation and the Philco Corporation. During the war he served with the U.S. Navy as a specialist on aircraft radar and radio equipment.

The recent addition of new, long-range, high powered radar equipment to the facilities of the Civil Aeronautics Administration Air Traffic Center in New York is an important factor in making this center the most complete of the 31 Air Traffic Centers operated by the C.A.A. in the United States and overseas. This radar equipment is utilized by the New York Center in its job of controlling the greatest density of airways traffic in the United States. The New York Air Traffic Center exercises control over 30 terminal airports, 12 military air bases and innumerable private airports, operating over 3,400 linear miles of low frequency airways and 4,200 linear miles of high frequency airways. In addition, another 3,500,000 square miles of ocean control area is the responsibility of this large Center. During the fiscal year of 1955 alone the Center handled 1,904,444 fix postings, averaging 5,128 for every 24-hour period. (A fix posting constitutes a report to the Air Traffic Center made by an enroute aircraft to identify its position).

With the density of air traffic constantly increasing and with the imminence of the commercial jet age, the use of radar equipment has become a necessity for the tight control which will be required to properly handle air traffic problems. The radar unit which is employed at the Air Traffic Center was manufactured by General Electric and is a modified version of the FPS-8 radar equipment, of which hundreds are in service throughout the United States and abroad. The C.A.A. designation for this type of radar equipment is T.A.S.R. (Terminal Air Surveillance Radar).

The antenna and transmitter-receiver building located at New York's International Airport, is connected to Civil Aeronautics Administration's new Air Route Traffic Control Center also located on the airport. Radar data are presented to the controllers on thirteen General Electric radar scopes at the Center.

By the use of this radar equipment, controllers can identify and maintain surveillance of all traffic operating under Instrument Flight Rules clearance which falls within the greater-than-one hundred mile range of the radar equipment. The controllers, continuously monitoring the radar indicators, can by radio contact maintain a safe distance of separation between airliners, effecting a much more efficient use of air space than was possible by former methods. When " manual " or " fix posting " control procedurers alone are utilized, aircraft report their positions as they pass over certain position fixes scattered along their routes. The position reports, coming into the Center, give essential data regarding the flight, including time of arrival over the next fix plus enroute altitude. These position reports are recorded on rectangular flight strips mounted in aluminum holders. Hundreds of these flight strip holders are arranged in slanting flight boards dispersed throughout the control room. In all, there are a total of 61 individual flight progress boards at the Center. These boards are distributed around the room in such a manner that control of aircraft can be passed from one board to another as the aircraft moves to an adjoining sector. Similarly, as the aircraft changes altitude within a sector, its flight strip can be altered in vertical position on the flight board.

The chief limitation when working completely with the fix posting and flight strip method and without any radar control is that an aircraft cannot be cleared for passing a fix until at least ten minutes after another aircraft has passed the same fix, unless it has a 1,000 foot altitude separation from the other aircraft. Assuming an average cruising speed of 360 miles per hour, 10 minutes of separation is equivalent to a longitudinal distance of 60 miles. Jet airliners, on the other hand, may maintain an average speed of 600 miles per hour, in which case a 10 minute separation would become equivalent to a 100 mile spacing. By the use of radar control, however, aircraft separation can be reduced substantially with no more than *five* miles of separating being required. Accordingly, the use of T.A.S.R. radar can expedite aircraft arrivals at terminals so that they fall within the capacity of the airfield.

The T.A.S.R. radar units operate in conjunction with shorter range radars located at the control towers of nearby airports—Newark, Idlewild, La Guardia and Mitchell AFB—to monitor arrivals and departures under both Instrument Flight Rules and Visual Flight Rules. The radar controller in the control center, on incoming flights, maintains contact with a given aircraft until it comes within range of the shorter range radars located at these other airports. At this time, he turns control of the aircraft over to the individual airport for final landing procedure.

The T.A.S.R. radar operates in the L Band (1,280-1,350 Mcs.), has a pulse repetition rate of 360 pulses per second, a pulse width of 3 microseconds and a pulse power output of 1 megawatt. MTI (Moving Target Indication) features of the coherent video cancellation type are included for minimization of any ground clutter effect.

Dual channel provisions will shortly be included in the basic C.A.A. setup so that in the event of a requirement for maintenance, the unit in question may be shut down for servicing without interruption of the radar control facilities.

The radar antenna consists of a parabolic reflector which produces a cosecant-squared beam, plus a dual feed horn mounted at the focal point of the reflector. The dual feed horn is fed by horizontally polarized energy from the radar range guide by vertically polarized energy from an IFF coaxial line, both handled through a rotating joint in the antenna pedestal (the IFF line is used for identification of an indivi-

dual aircraft). When queried in flight, this aircraft sends back a return message which appears on the radar scope adjacent to the aircraft's normal traffic echo, thus identifying the specific aircraft involved. In the event that an aircraft is not equipped with IFF facilities it is possible to identify it by requesting, via radio, that the pilot execute a particular maneuver. The new position of the return radar signal will then identify the plane involved.

The antenna is designed so that aircraft returns can be received from altitudes of 1,000 feet to over 40,000 feet. Beam width in the horizontal plane is about three degrees, assuring a good definition on the radar screen. The antenna can be manually adjusted in tilt between —2 and +5 degrees from the horizontal. At the Center the antenna and transmitting equipment is located 2,000 feet from the control room itself. The antenna is mounted on a steel tower 77 feet high. (Antenna height at any site is determined by the operational requirements at that particular site.)

The antenna and rotating assembly, weighing approximately three thousand pounds, is connected to the equipment in the adjoining building at the base of the tower by wave guide, coaxial and multiple conductor cable. Total power consumption is approximately twenty kilowatts and the unit is operated continuously 24 hours daily. The antenna rotates 360 degrees in a clockwise direction at a rate of approximately 6 rpm.

A total of 13 PPI (Plan Position Indicator) units are located at the Center. PPI units are identified by a rotating sweep revolving in exact synchronism with the radar antenna. A PPI unit plots slant range versus azimuth angle throughout its entire rotation. A target indicated on the scope can be immediately identified as to its slant range and azimuth by direct reading off the face of the indicator.

As an aid in positioning aircraft with regard to surrounding geography, video maps are utilized which super-impose the geography of the area upon the scope. The controllers can see instantly on the video map the location of fixes and navigational aids that he requires in order to more easily direct the aircraft to its destination.

Six of the 13 PPI units in use at the Center are arranged for horizontal presentation, while the remaining seven are arranged in standard vertical fashion. Horizontal presentation is accomplished by magnifying and projecting the image on a four inch cathode ray tube through a Schmidt optical system to the surface of a flat, frosted-glass table. An image 24 inches in diameter is obtained on the horizontal units. Horizontal presentation has the advantage of permitting small plastic tabs to be placed on the surface of the indicator so that the progress of an individual aircraft can be more easily followed. These tabs also contribute to the constant identification of a given "blip". The six horizontal presentation indicators are located in the center of the C.A.A. control room, while the vertical scopes

Controllers engaged in controlling air traffic in the New York Air Route Traffic Control Center. They are using the new General Electric FPS-8 radar units installed in the new center. These scopes take the video presentation from the radar and project it on horizontal glass plates in magnified form, thus simplifying plotting.

are interspersed between the flight control boards along 3 sides of the room.

At many of the major air terminals throughout the world the air traffic control is already out of hand, with one half hour delays in stacking being quite common, even under VFR conditions. In ten years it is expected that the present volume of air traffic will triple. This will result in still longer stacking delays over each airport if the present systems of air traffic control are not improved.

Thirty-five years ago the first night flight of air mail in the United States was completed. The pilot was guided by bonfires, flares, an automobile road map and a fair share of luck. We have come a long way forward since then in improvement of air traffic control techniques. The C.A.A. is even now experimenting at its technical development center in Indianapolis with a computer which will automatically relay necessary flight information to the pilot.

The application of FPS-8 radar to long-range control problems represents a major and highly significant advance on the road to eventual automation of control procedure.

The scope is one of thirteen located in the Center which present radar data from the General Electric FPS-8 long range radar.

The same scope in operation.

Radar Network for Traffic Control in Canada

The Canadian Government has approved the erection of a chain of fifteen radar stations whose construction costs are estimated at $5,000,000. Equipment will be supplied from the spring of 1958 onwards by Raytheon Manufacturing Company [1] and installed at Canada's fifteen major airports (Moncton, Seven Islands, Quebec, Montreal, Ottawa, Toronto, London, North Bay, Fort William, Winnipeg, Regina, Saskatoon, Edmonton, Calgary and Vancouver).

The equipment, designated Airport and Airways Surveillance Radar (AASR), will make it possible to keep aircraft flying between any of Canada's 15 major airports under close observation, even in stormy weather. While the Canadian Department of Transport's specifications called for a radar capable of tracking a plane at a distance of 120 miles, Raytheon engineers are confident that their equipment will permit each airport to track large commercial airliners within a radius of up to 200 miles. This estimate, it was pointed out, is based on the actual performance of more than 1,000 Raytheon military air search radar units now used by the U.S. military forces. Because Canada's principal airports, with but one exception, are no more than 400 miles apart, the overlapping patterns of radar surveillance will provide almost continuous coast-to-coast coverage.

An important advantage of the equipment, which permits the operator to select either linear or circular polarization of the radar signal, is its ability to detect and track aircraft in rain and other bad weather.

Linearly polarized radar is often unable to " see " targets in storm-clouds, since target and clouds both reflect the radar beam. To eliminate this handicap, the antenna of Raytheon's new AASR can apply circular polarization to the outgoing beam. When these " twisting " microwaves strike the storm-cloud, millions of spherical raindrops bounce them back to the antenna with a reverse twist. Their path to the receiver is blocked by an electronic filter so that they cannot register on the radar scope. When the microwaves strike the irregular surfaces of a solid object such as an airplane, many of them return to the antenna retaining their original twist. Thus they pass unhindered through the electronic filter to the receiver and register as targets on the radar scope.

Another feature is Moving Target Indication, a built-in ability to select only moving objects, by filtering out reflections from fixed objects, such as buildings, mountains and other undesirable reflections, from the radar viewing screen. To pinpoint the exact geographical location of the aircraft at all times the operator superimposes onto the face of the radar scope an electronically-generated map of the territory over which the aircraft is flying.

The giant, 40-foot antenna used with this equipment was especially designed not only to provide a 200-mile scanning range but also to permit the tracking of planes flying as high as 70,000 feet. The favourable altitudes for efficient jet operation are at 35,000 feet or more, and it is at these heights at which air traffic will become congested. The antenna is also equally effective for low-altitude coverage.

Chances of a breakdown of the radar coverage are reduced because the equipment has been constructed, in effect, as two systems in one, with dual controls and functioning parts permitting uninterrupted operations through either system.

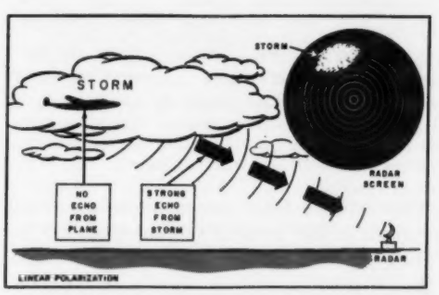
The system " criticizes " its own operations through monitoring devices which operate automatically and continuously to keep even unskilled operators informed at all times of the radar's working efficiency.

The reliability of the system, Raytheon engineers point out, is a result of Raytheon's intensive experience with the development of the DEW Line early warning radars which guard America's northern continental approaches, and the long-range air search radars for the U.S. Navy's new picket submarines, " Sailfish " and " Salmon ".

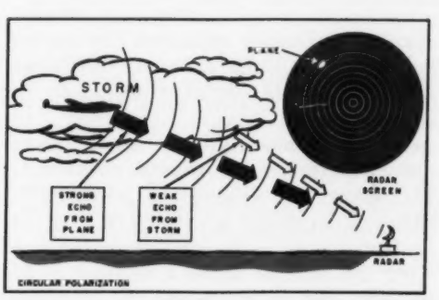
A statement issued by George C. Marler, Canadian Minister of Transport, says : " When the new equipment has been installed, Department of Transport air traffic control units will have a radar coverage of approximately 400,000 square miles. The equipment in question is believed to be the first of this type to be ordered by a civil agency for air traffic control."

[1] Microlambda, of Naples, Italy, also produces, under Raytheon licence, radar equipment whose data correspond largely with the equipment for the Canadian network.

The observer sees on the radar screen the echoes from the aircraft and an electronically superimposed map of the control area. Permanent echoes from buildings or hills are filtered out.

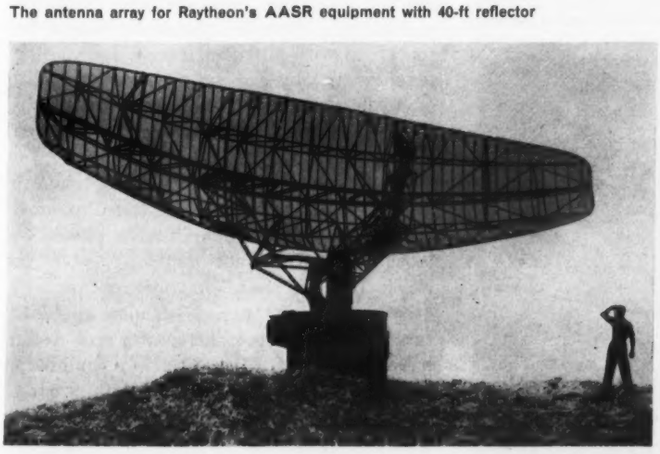


Radar equipment with linear polarization of radiation receives a strong echo from a cloud, which swamps the weak aircraft echo.

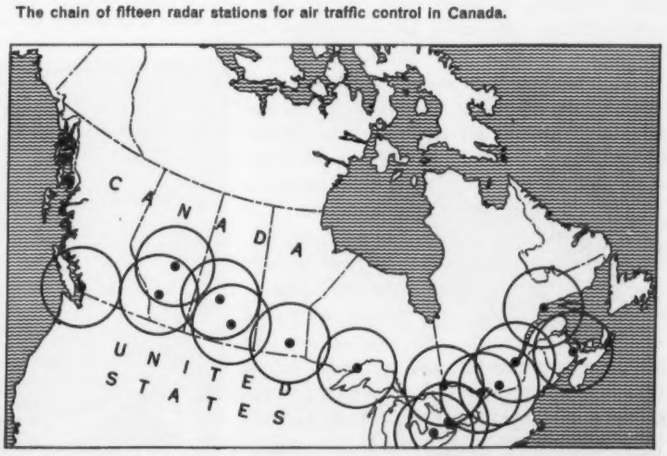


With circular polarization the cloud echo is suppressed. The aircraft echo now appears clearly on the screen.

The antenna array for Raytheon's AASR equipment with 40-ft reflector



The chain of fifteen radar stations for air traffic control in Canada.



Constant-Pressure Separation for Aircraft

by A. J. FERREIRA, Lisbon

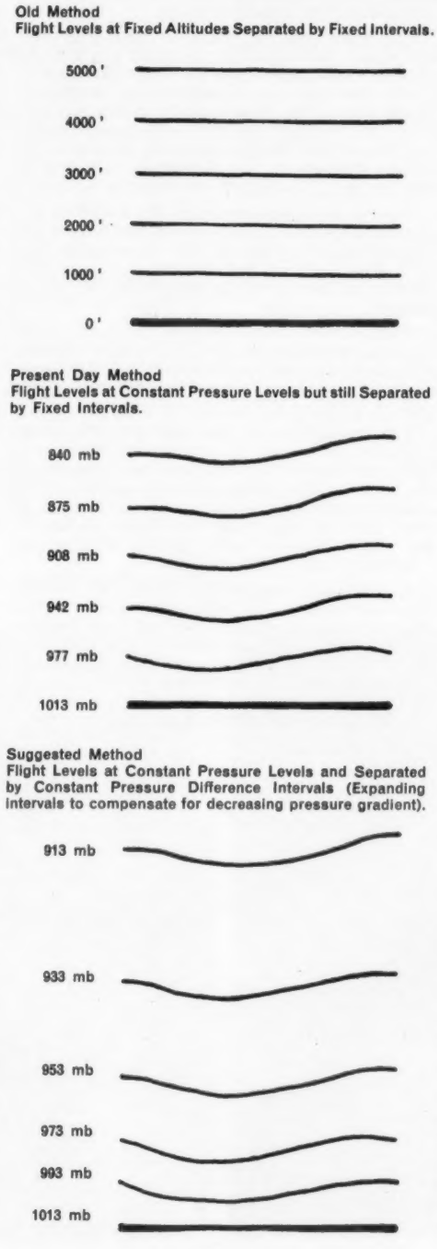
Today the safety of air navigation implies a thorough job of traffic control. The actual job of controlling air traffic is a continuous process of forecasting future positions of aircraft and altering their movements whenever such forecast reveals a likelihood of a dangerous situation arising. To alter their movements the controller needs airspace, and as the number of users increase the airspace becomes crowded. *A more economic allotment of airspace would be appreciated.*

*

We will be here concerned with a brief analysis of the vertical spacing of air traffic along the same routes. For economic reasons that spacing should be very short and for safety reasons it must be large enough. A vertical distance of 1,000 feet has been adopted by I.C.A.O. as standard separation. This separation is theoretically the same everywhere but *the margin of safety it is intended to provide is definitely not the same.* In fact we don't have an " altimeter " in the true literal sense of the word and must depend on an indirect method using a " barometer " to measure atmospheric pressure which, among many other things, also depends on altitude. Furthermore the relationship pressure/altitude does not change at a steady rate. In the conventional I.C.A.N. atmosphere the first 1,000 feet interval shows a decrease of 36 millibars, but at 20,000 feet the difference is only 20 millibars, and still much less at 40,000 feet. The more we climb in the rarefied upper atmosphere the less use the barometer becomes. Its relative loss of sensitivity with altitude (increases in percentage of instrumental error vs. pressure change) causes our margin of safety to become less and less effective. It is no use to say that the vertical distance is always the same, because we cannot at any level measure it with the same accuracy. *Our instrument measures pressure, pressure intervals are different.*

It may be asked why we stick to this system of separating levels by *fixed altitude intervals* justifiable only for the low levels of the atmosphere that were in use when the system was created. As long as no real altimeter is available and we must go on using a barometer instead, we might perhaps separate flight levels by *constant pressure difference intervals.*

As an example, a 20 millibars difference (which is the present day separation for traffic at about 20,000 feet) might be taken as the acceptable standard of safety. We would be able to use 27 different levels from sea level to 20,000 feet : *a net gain of 7 levels in the most crowded half of presently commercially used atmosphere.*



This would be a happy solution if the present day separation at 20,000 feet could be considered enough which, it is to be feared, is not the case, unless some substantial improvement can be made in determining altitudes.

Otherwise the 36 millibars difference interval provided at sea level would have to be maintained all the way up. The advantages of the method of constant pressure difference interval proposed here would be just as welcome regardless of the minimum safe difference adopted.

The reasoning involved runs along the same lines as I.C.A.O. followed when it was led to replace the old system of flying at *fixed altitudes* by the present systems of flying at *constant pressure levels.*

I.C.A.O. has already very wisely corrected the first part of this inadequate method ; we may now expect that the second part will be corrected in the same way. Due to a " Recommendation " of the 3rd Air Traffic Regional Meeting for the Europe-Mediterranean Region I.C.A.O. has embarked on an extensive study of the problem, which is rather more involved and depends on many more items than the one considered here.

*

As regards altimeter readings, the proposed method would offer us an opportunity to settle the dissension between those who believe that altitudes should be stated in feet and those who prefer that they be stated in metres. Since we should no longer be concerned with altitudes (except for landing procedures) why not satisfy ourselves with indications in terms of pressure that the altimeter gives us, just like a barometer, which it is ?

In the system of " flight levels " in use today, I.C.A.O. has already advised us most emphatically that the flight levels should be labelled by " abstract numbers " with no implication of " feet " or " metres " or any other unit of distance. This idea would be carefully preserved. The control unit would have one aircraft flying at 465 (millibars) and the next one below at 485 (millibars). Not the slightest confusion in altitude could possibly arise.

Missile Note-Book

Editor's Note: **The June 1956 issue of *Interavia, Review of World Aviation*, provided a broad survey of the present state of guided missile and rocket engineering as well as of allied problems such as guidance, navigation etc. It was completed by a study of the strategic implications of the expected advent of Intercontinental Ballistic Missiles (I.C.B.M.) and of shorter-range weapons. While a cloak of stringent secrecy surrounds missile development in every major country, small tid-bits of information are nevertheless released by the authorities at frequent but irregular intervals. In order to keep its readers currently informed on the rapidly growing missile activities in every part of the world, *Interavia Review* will from time to time publish a summary of the latest developments in the new and vast field of missile engineering. The first of these summaries follows.**

A glimpse into the future—a realm of fiery, high-thrust rockets — was provided by North American Aviation a few weeks ago. The North American Aviation Rocketdyne Division put on view its Propulsion Field Laboratory located in an isolated section of the Santa Susana Mountains some 35 miles northwest of Los Angeles. Here are seven giant test stands, some capable of handling 1,000,000 pounds of thrust. Currently under development is an undisclosed 350,000 pound thrust rocket engine combination, a 135,000 pound thrust booster rocket for the *Atlas* Intercontinental Ballistic Missile, a 100,000 pound thrust sustainer rocket (also for *Atlas*), plus engines for the *Redstone* artillery missile, the *Thor* intermediate range missile, the *Titan* I.C.B.M., the *Jupiter* I.R.B.M. and the *Navaho* intercontinental missile. *Thor* is the 1,500 mile range I.R.B.M. being built by Douglas for U.S.A.F. and *Jupiter* is another I.R.B.M. derived from *Redstone* and being built by Chrysler Corp. as a ship-launched rocket under Army-Navy sponsorship. *Titan* is the second U.S.A.F. intercontinental ballistic missile, with Martin as the prime contractor. *Titan* programme is being run parallel with *Atlas* but will be centred at Martin's new Denver, Colorado facility. Thus, North American Aviation is working on virtually every U.S. war engine of the future.

Fate of the U.S.A.F.'s Northrop SM-62 *Snark* surface-to-surface missile still has not yet been decided. Accuracy claim is that ultimately the cruise missile (a star tracker) could come within 120 feet of its target at a range of 5,000 miles (present range is believed to be a little more than 2,000 miles). Meanwhile, tests are continuing on another intercontinental cruise missile, the North American *Navaho*. The latter missile is now designated as SM-104A and is undergoing tests at Patrick A.F.B., Florida.

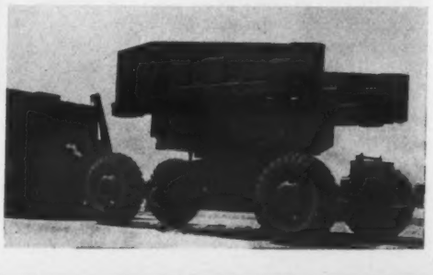
During this interim period, the missile power of the U.S. Navy has been moving up to the point where it is disturbing the Air Force. The *Regulus* was recently launched from the deck of the sub *USS Tunny*. In addition, the attack submarines *USS Grayback* and *USS Growler* and the SSGN (nuclear powered submarine) now under construction are to be equipped to handle *Regulus* missiles. The U.S. Navy has admitted that the U.S.S.R. has about 400 submarines now—many of which could launch missiles—and is building about 50 modern submarines a year. Perhaps this is why the Navy is intensifying its air-to-surface missile programme. The Navy has recently unveiled its *Petrel* missile. *Petrel* is electronically guided from its mother craft. Power comes from a J-44 turbojet engine. Range of *Petrel* is claimed to keep the mother plane out of reach from enemy ship defences. The Navy air-to-air *Sparrow I* missile is now in operation on the Chance Vought *Cutlass* on both the Atlantic and Pacific. The McDonnell *Demon* fighter is also being prepared for the missile. The Air Force *Falcon* will be used only on the Northrop F-89H, McDonnell F-101, and the Convair F-102. However, the Air Force has crossed the Navy line and is adopting the use of the Navy-developed *Talos* ground-to-air missile. Continental Air Defense Command will use *Talos* for protection of its bases. The installations will be manned by Air Force personnel. The Army feels that it is being " phased out " of the anti-aircraft picture. In addition to the *Talos* affair, the Air Force *Bomarc* (IM-99) appears to loom as an eventual replacement for *Nike*. However, the only consolation the Army may now have is that *Bomarc* is now only in the " prepare for production phase ".

Latest information on the *Vanguard* satellite vehicle indicates that it will be about 72 feet tall, have a maximum diameter of 45 inches and have a launching weight of some 11 tons. Guidance will be located in the second stage and will consist of a gyro reference system to detect deviations from the proper trajectory and an autopilot to relay correction information to the gimbal-mounted rocket motor. Third stage solid propellant rocket will be spin-stabilized. Shape and size of the actual satellite have not yet been determined. The satellite may weigh anything up to 20 pounds. Instrumentation from satellite to satellite will also vary. Naval Research Laboratory has developed the *Minitrack* for use on the satellite. *Minitrack* weighs 2-3 pounds and operates at a power output of 10-50 milliwatts (on the 108 mc band). Operation will be with a zinc-silver battery. Miniature tubes rather than transistors will probably be used. The satellite will be ground tracked and the track information will go to a computing facility to determine the exact orbit. *Minitrack* will be triggered from the ground to telemeter research data when it passes over a ground receiving station.

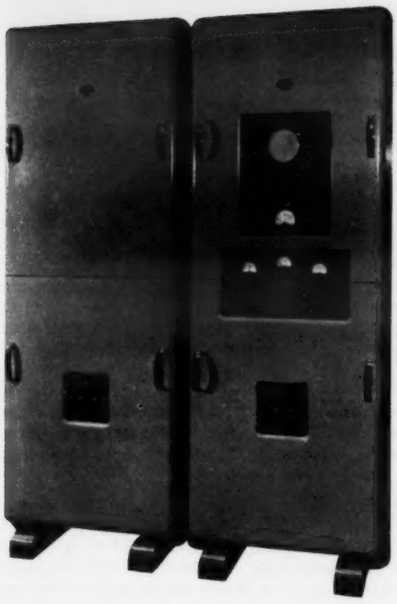
Solid rocket propellants have also been in the news. *Phillips Petroleum Co.*, operator of the Air Force propellant Plant No. 66 at McGregor, Texas, says that one of its solid propellant engines has hit a thrust rating higher than any known single rocket. Highest World War II thrust rating from a solid propellant was the 143,000 pound thrust of the *Rheintochter* booster. Current I.C.B.M. engines (liquid propellant) are in the 125,000-150,000 pound thrust class. The Phillips propellant is a low cost material made from synthetic rubber, carbon black, and ammonium nitrate (the latter is a common fertilizer material). *Thiokol Chemical Corp.* reports that its solid propellant was used in the General Electric-Army Ordnance RV-A-10 rocket. Claimed to be one of the world's largest solid propellant rockets, the missile appears to be a version of the General Electric *Hermes* (which, in turn, is a modified *Wasserfall*). Thiokol is also establishing a $2,000,000 rocket plant in northern Utah. Solid propellant rockets —weighing 3 ½ pounds —will soon be used by U.S. infantry troops as a foxhole digger. Another novel use for solid propellants is a hypodermic rocket. *Redel, Inc.* has such a unit using nitrosoguanidine as a propellant. Throat diameter is only 0.005 inch. The charge supersonically injects nerve gas antidotes Ce. g. atropine into the tissue without puncturing the skin !

Test launchings of U.S. missiles are made at Cape Canaveral, Florida. Important flight data are transmitted to the ground by instruments in the missile. Picture shows the spiral antenna for the reception of these transmissions. The operator keeps the antenna constantly trained on the missile.

Convair/Bendix Terrier beam-riding two-stage anti-aircraft rocket ready for firing from a twin launcher; the twin launcher in transport position.



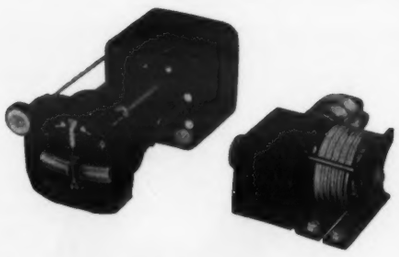
Equipment Round-Up



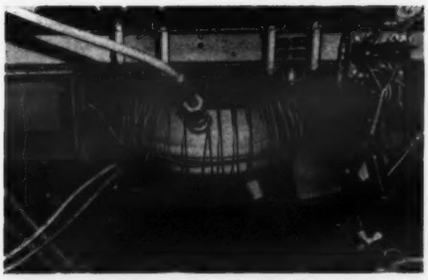
● **Canadair Limited,** Montreal, recently took into service this template camera for glass negatives measuring 40×48 ins. The drawing to be enlarged is copied on a glass negative and then projected on to sensitized metal plates held to the copy by vacuum. In this way template photos up to 16×6 ft. can be made. ▶

● **Mullard Ltd.,** Equipment Division, London, has developed a radar simulator capable of producing artificially the tracks of up to twelve aircraft. Designated the Mullard Radar Trainer SL.21, it is intended to be used primarily for ground control interception radar. Each " artificial aircraft " is controlled from a pilot's unit having controls for speed of flight and rate of turn. Indicators on the pilot's unit show heading, " eastings ", " northings " and the distance of the " aircraft " from the radar station.—The trainer can be used in conjunction with a live radar or it can simulate an aerial transmitter, with variable pulse repetition frequency, scanning speed and beam width.

● **Hamilton Standard Division,** United Aircraft Corporation: A type FAS 700-4 fuel-air starter has been in use on the Boeing 707 prototype for almost a year. It operates in much the same way as a gas turbine engine. Compressed air, from a storage bottle in the aircraft, is combined with JP-4 fuel from the aircraft's normal supply and ignited. The gases are directed against a small turbine wheel and turn it at high speed. Power output from the turbine is geared down and cranks the J-57 to starting speed. Three starts can be made with the air pressure in the bottle, which is then recharged during flight from a small electric compressor inside the aircraft. The starter is fitted on the 707's No. 1 engine and starts it in less than 20 seconds. Once the first engine is started, its compressor section supplies air pressure to start the other three engines.



● **Air Associates, Incorporated,** Teterboro, New Jersey, manufactures a new low-cost single-axis automatic rudder control for light and medium aircraft, which utilizes the gyroscope of a standard turn and bank indicator to sense and control turn rate. Known as the DART I (from its function to control Direction and Rate of Turn), the unit consists of only two components, a turn sensing unit (left) and an actuator (right), connected by a single cable. Weight, 3 lbs.; price $495.



● **Normalair Limited,** Yeovil, England: Liquid oxygen system (built under Bendix licence) to supply oxygen for crews at high altitudes. Picture shows the liquid oxygen converter (capacity 5 litres), which gives a gaseous supply equivalent to that provided by six standard 750-litre storage cylinders. —Flight tests in a **Meteor NF.11** jet fighter are to be followed by trials in a **Canberra B.2** bomber.

● **Allied Instrument Manufacturing Corporation,** Houston, Texas, supplies a device for warning when propellers must be feathered in multi-engine aircraft. Named " Safeather", the device consists in essentials of a sensitive torque measuring instrument fitted on the engine mount near the firewall, and a warning lamp in the pilot's feathering button to indicate the moment when torque changes after an engine failure. The sensing unit detects the exact moment when the propeller stops delivering thrust and begins to cause drag. The warning lamp thus tells the pilot just when feathering action is needed and avoids the faltering engine being cut earlier than is strictly necessary.

● **Lockheed Aircraft Corporation** announces a miniature television camera for use in flight testing. The equipment measures 1¾×2×5 ins., weighs only 1½ lbs. and can be mounted in relatively inaccessible parts of the aircraft.

● **Northrop Aircraft Company** has developed a vibration test stand of less than 1 cu.ft. in volume to check resistance to vibration in components of the SM-62 **Snark** guided missile. It can be used to test the effects of frequency vibrations ranging from 5 to 600 c/s and of forces up to 55 g. The heart of the device is a two-stage electro-hydraulic servo valve built by Bertea Products Co., of Pasadena, Cal., which enables vibratory forces to be exerted on a test specimen from several different directions.

● **Lear, Incorporated,** has applied for patents on a small " black box " having man-like powers of deliberative judgment, which will first be used for air navigation. The device follows precise rules of logic in reasoning whether to accept, reject or demand confirmation of data fed into it. — In its immediate airborne application the system is called the Lear SCAN, meaning Self-Correcting Automatic Navigator, and will make use of reflected VHF signals far beyond the line of sight to guide the aircraft straight to its target. Military aircraft fitted with the device could thus fly at low altitudes where they are safe from detection by enemy ground radar. Only those signals are accepted which fall within the error limits of the airborne navigating system. Once determined valid, the good radar data are used to correct automatically the reading of the airborne system.

● **Scintilla Division, Bendix Aviation Corp.,** Sidney, New York, produces a polyvinyl material called Scinseal which is being used to provide sealed metal conduits for high tension leads. It may be applied by spread coating, casting film, dip coating, slush moulding, cavity moulding, injection moulding, extrusion or spraying.

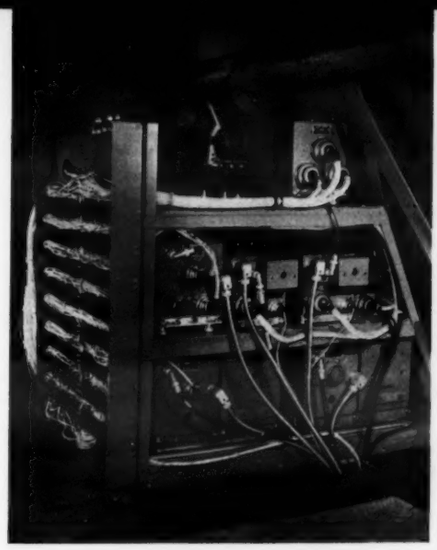
● **Saro Laminated Wood Products Ltd.,** of Whippingham, Isle of Wight, supplies a rigid high impact plastic sheet that can be formed into quite complex shapes. The new product is called Saroy High Impact Sheet and is made of Styron 475, a modified polystyrene manufactured by Distrene Ltd. It has three to five times the impact strength of general purpose polystyrene, ten times the latter's elongation, good dimensional stability, low water absorption, good durability, and is non-toxic.

● **Philco Corporation,** of Philadelphia, Pennsylvania, has developed a system for the remote transmission of aerial photographs. Two television cameras in the aircraft transmit their pictures direct to ground stations, where they are projected on a 35-mm film strip.

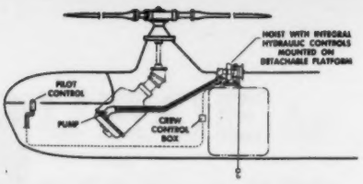
● **Hiller Helicopter Corporation** has designed for Air Research and Development Command, U.S. Air Force, a folding rotor that can be retracted into the wing and could be used, for example, in convertible aircraft.

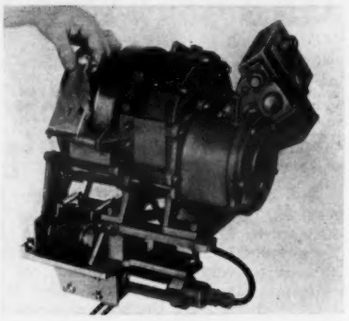
● **S.N.C.A.S.O.,** Paris, is testing a new fully automatic ejection seat, the Type E.120, which is especially suitable for use in VTOL aircraft and meets all important requirements for safety equipment at low altitudes : rapid separation of the pilot from his seat ; immediate opening of the parachute. Ejection is initiated by a telescope-like cartridge (of S.N.C.A.S.O. design) similar to that used in the company's E.96 and E.101 ejection seats. An automatic device is provided to release the pilot from the seat before it reaches the top of the ejection curve ; at the same time the parachute envelope is ejected from its bag by a mechanism not described in detail.

● **DEUTAG-Mischwerke,** Cologne-Deutz, Germany, has developed a kerosene-resistant joint-filling material for jet aircraft runways, which has already been used successfully at a number of West German airports and air bases. The material, known as Antipetrol, is immune to attack by any petroleum distillate or oil deposit and has also a high resistance to heat. Pouring temperature is 150 to 160° C, specific weight 1.35.



● **Aircraft Radio Corporation,** of Boonton, New Jersey, is demonstrating ARC radio communications and navigation equipment in a Beech **Twin Bonanza**. The full equipment, visible here only in part, includes dual Type 15 D VHF navigational receiving equipment, dual Type 21 ADF, R 19 VHF communications receiver and three T-21 VHF transmitters (providing 30 transmitting channels), R 20 marker beacon receiver, dual CD-1 course directors, F-11 A isolation amplifier and glide slope receiver.

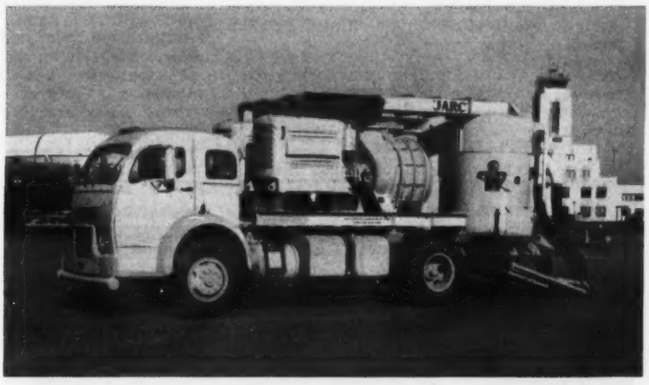




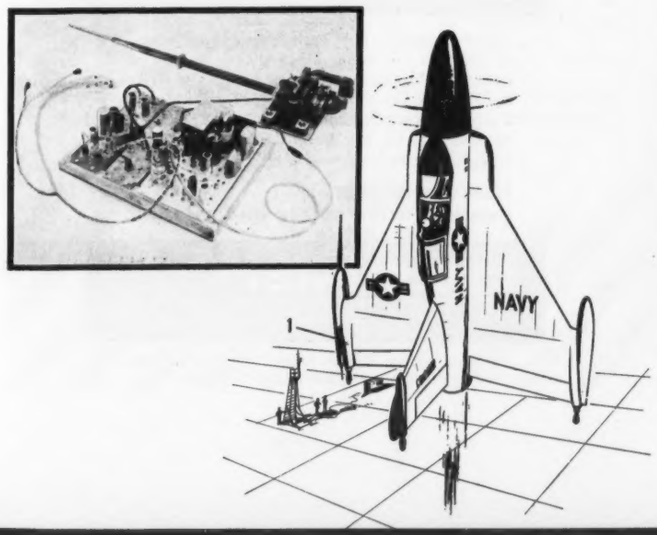
● **Vickers Incorporated**, Detroit, Michigan, produces a personnel rescue hoist system designed in particular for use in helicopters. It is provided in " packaged " form for maximum flexibility in installation and maintenance and is operated by a hydraulic pump (cf. top drawing). Permanent installation required is merely two hydraulic lines plus electrical control switches and their wiring. ▶

● **Compagnie Française Thomson-Houston** and Compagnie Générale de Télégraphie sans Fil have jointly developed a fire control system for medium-calibre anti-aircraft guns (40-mm Bofors etc.), which has now been recommended for purchase by the French Army after four years of testing by the Directorate of Armament Research and Production. The installation, mounted on a four-wheel trailer, consists in essentials of a range and bearing radar with automatic target tracking, an optical sight for visual target tracking and a computer.

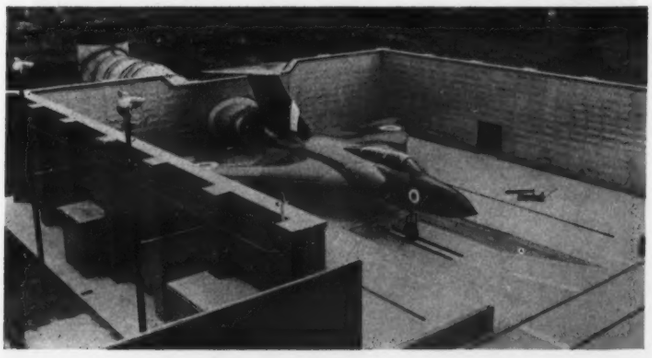
● **Hoffmann Machinery Co.'s** Air Appliance Division, New York: " JARC " = Jet Aircraft Runway Cleaner is the designation of a vacuum runway cleaner installed on a truck and capable of being operated by a single man. The suction nozzle at the end of the truck picks up all dust and small particles and sucks them, as in an ordinary vacuum cleaner, through flexible pipes into two vertical filter drums. The equipment can clean approx. 2,000,000 sq. ft. of runway area in eight hours.



● **The Convair Division** of General Dynamics Corporation, San Diego, California, has fitted a rate-of-descent indicator, which measures the variation per second in height above ground on the doppler principle, in the XFY-1 **Pogo Stick** experimental VTOL aircraft. The equipment, which weighs only a few pounds, consists in essentials of a doppler radar working in the X-band (transmission frequency 10,000 mc/s) which uses the ground below the aircraft as a reflecting surface.—When ascending or descending the pilot sights over his left shoulder towards the ground. In his line of sight is the up-and-down meter mounted to the rear of the seat. The actual rate-of-climb radar is housed in the left wing pod. An additional aid is provided by the use of four coloured lights installed on the pod and also in the pilot's line of sight; each light indicates a different velocity range.



● **Hawker Siddeley Group:** A fixed twin-jet aircraft silencer pen for the two engines in the Gloster **Javelin** all-weather fighter has been opened by the Hawker Siddeley Group at the Gloster Aircraft Company's Hucclecote, Gloucester, airfield. The £25,000 silencer completely muffles the noise from the two **Sapphires** during test runs on the ground. Normal conversation can be carried on just outside the pen.—The silencer consists of a 76-ft. long pipe, turned up at the end, and made up of a number of internal baffles and an expansion chamber. Experiments have shown that engine noise is caused not only by escaping gases but by vibration through the aircraft wings and fuselage. Therefore a 16-ft. insulating wall, lined with perforated aluminium, is built around the silencer.



Book Reviews

The Economics of European Air Transport.—By Stephen Wheatcroft. Foreword by Peter G. Masefield.—Manchester University Press, Manchester, 1956 (English ; 358 pages ; price 35 shillings).

The author, who served with the Fleet Air Arm during World War II, has been Economic Adviser to B.E.A. for the past ten years. In the present book he sets out to analyse clearly and objectively why European air transport —despite its seniority—has fallen behind the United States from the economic point of view. His review is by no means restricted to negative criticism, however, but also include constructives proposals for overcoming present difficulties—proposals which should not be ignored by air transport and economic circles. He.

Principios de Derecho Aéreo. By Alvaro Bauza Araujo. — Published by the Law Faculty of the University of Montevideo (Biblioteca de Publicaciones Oficiales de la Facultad de Derecho y Ciencias Sociales de la Universidad de Montevideo). Foreword by E. J. Couture, Dean of the Faculty of Law and Social Science, Montevideo, 1955 (Spanish ; 206 pages).

A concise, readily understandable introduction to air law, which the author—head of the Legal Office, Directorate General of Communications in Uruguay—has evidently tailored to meet the requirements of Latin American students of law, but which nevertheless gives a good overall international view. He.

El Helicóptero y su Regimen Jurídico. By Alvaro Bauza Araujo. Foreword by General Cesar M. Meiraldi, Director General of the Secretariat of State, Ministry of National Defence, Uruguay.—Published by Martin Bianchi Altuna, Montevideo, 1956 (Spanish, 143 pages).

The international helicopter congresses held almost yearly in Italy (Fourth Congress in San Remo) demonstrate the importance of settling the legal aspects of helicopter traffic on both an international and a national basis. The author's attempt to bring the subject to the attention of Latin American air law experts is therefore to be welcomed. He.

Famous Airports of the World. By John Stroud. —Frederick Muller Ltd., London, 1956 (English ; 143 pages ; price 8s. 6d.).

Nothing ages so quickly as airport installations. But this small " world history of ground organization " in pocket format will have a longer life. Its author, the well-known English aviation writer, has taken an imperishable phenomenon as central theme, namely development. An instructive book and by no means wearisome. He.

Famous Air Routes of the World. By Harold Champion.—Frederick Muller/Shakespeare Head, London, New York, Sydney, Paris, 1956 (English ; 143 pages ; price 8s. 6d.).

The writer, a commercial pilot who is at home on the air routes throughout the world, has seen a great deal more on his flights than just the instrument panel. An entertaining and well-rounded brief history of the world's air transport... from the day before yesterday to the day after tomorrow. He.

So geht es bei der Luftfahrt zu. By Klaus Hansen. Verlag Klasing & Co., Bielefeld, 1956 (German ; 257 pages ; price DM 12.80).

As the publishers' announcement states, this book was written primarily for those who gaze longingly at the runway from outside the airport fence and who find nobody to tell them what is going on and how things work. Supported by a wealth of good illustrations and tables, the author has succeeded in describing modern air transport to the layman in a conversational but entirely reliable manner.—At last a book on aviation without bombs, cannon or guided missiles. He.

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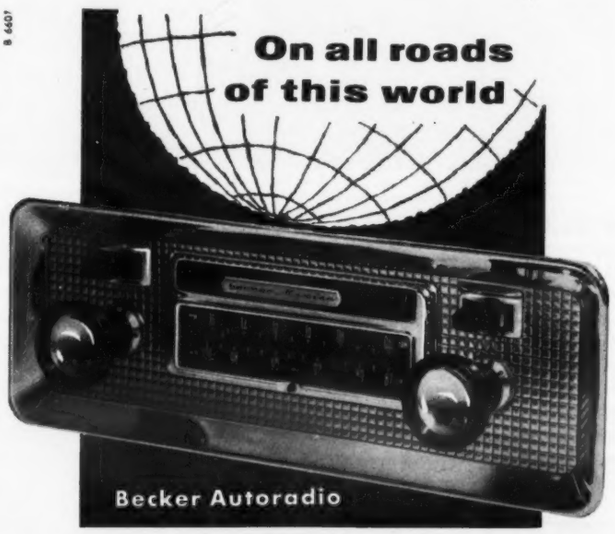

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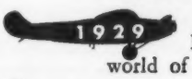
KLM inaugurates the world's oldest air service still maintained by the same company: Amsterdam-London.

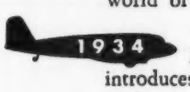
KLM opens the first air traffic booking office in the world.

KLM is the first to make use of air-cooled engines and all-metal propellers, also since 1920 the first to introduce to the world the Fokker passenger planes which later on became the most widely used commercial aircraft in the world.

1927 KLM makes the world's first intercontinental charter flight: Amsterdam-Jakarta and -Khartoum.



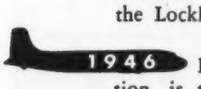
KLM opens the longest air route in the world of that time: Amsterdam-Jakarta.



KLM, as first airline outside the U.S., introduces the all-metal DC-2, wins the London-Melbourne Air Race handicap section.

1936 KLM is the first European company to purchase the world's most widely sold commercial aircraft: the DC-3.

1943 KLM, as first non-U.S. carrier, orders the Lockheed Constellation.



KLM, despite its war-shattered organization, is the first European airline company after the war to open a regular Trans-atlantic service to New York.

1948 KLM is the first European company to put the Convair Liners into service.

1950 KLM is the first European airline to be specially authorized by the U.S. Government to overhaul aircraft of U.S. airlines.

KLM is the world's first airline to operate the turbo compounded Lockheed Super Constellations.

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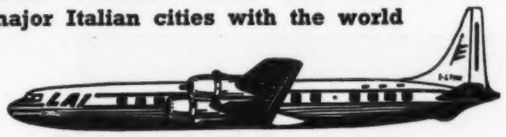

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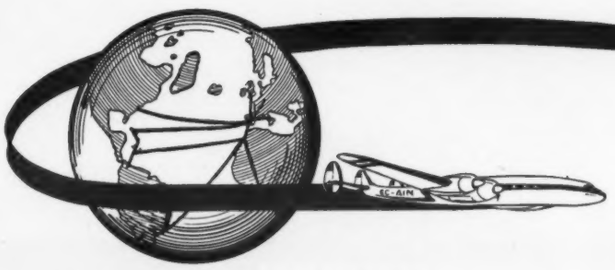

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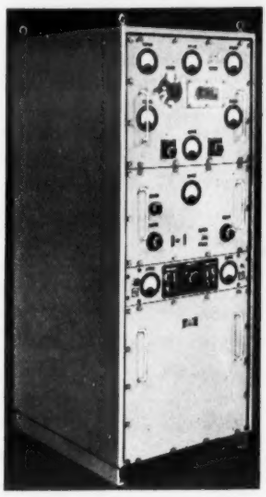

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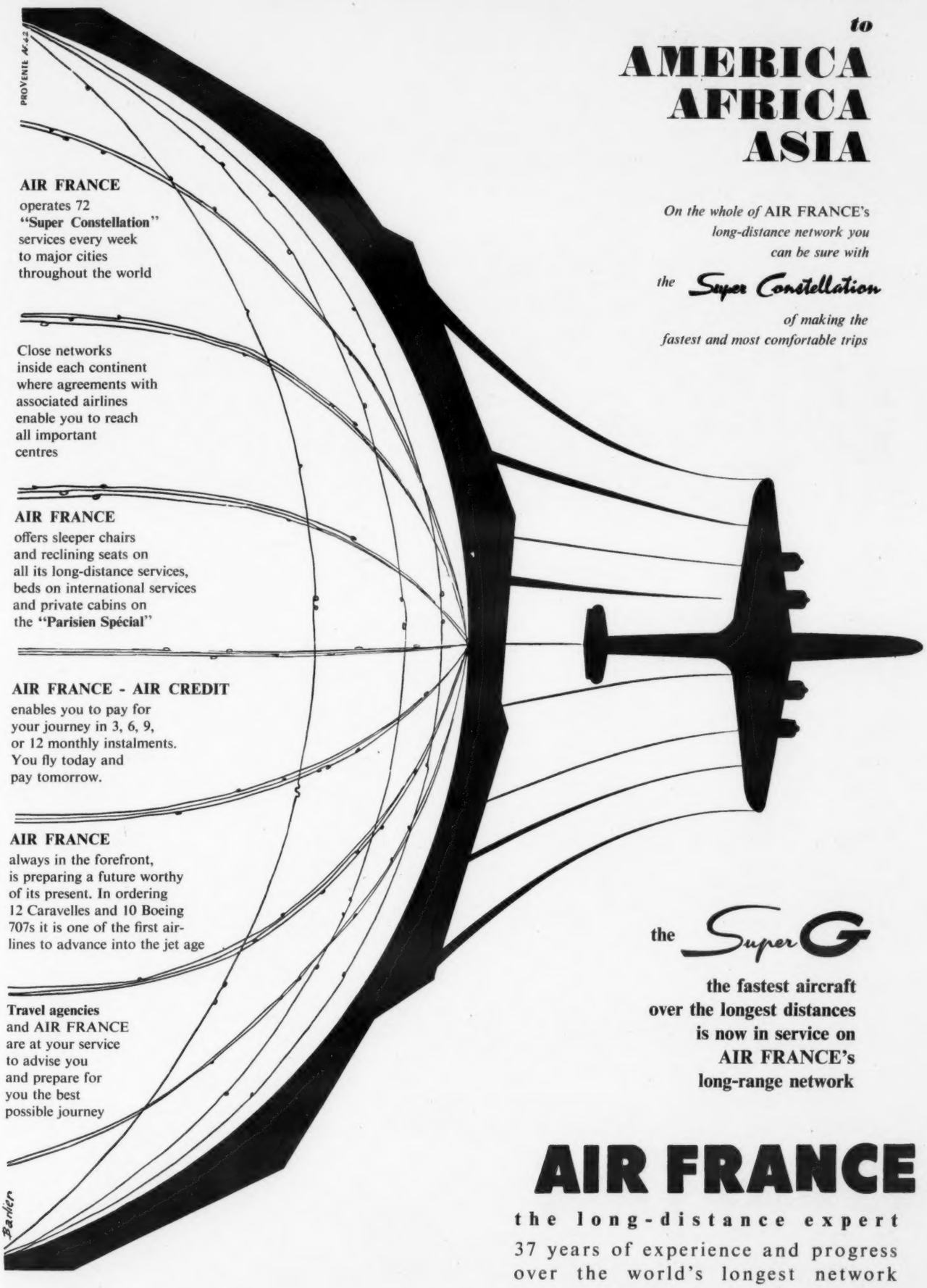

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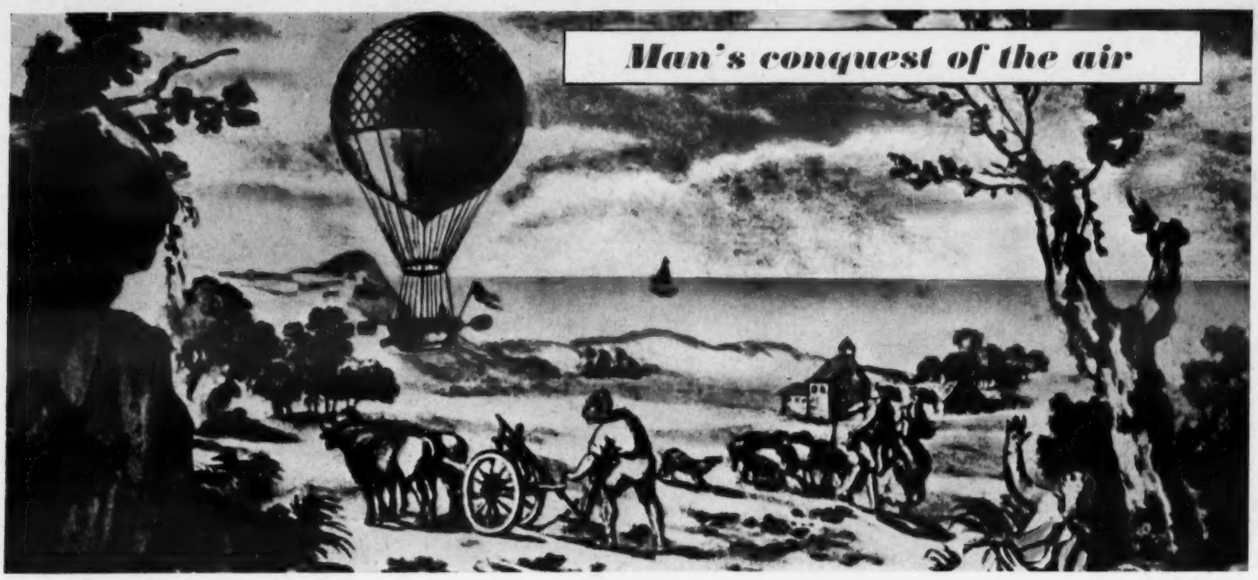

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In short order they threw into the sea everything from sand ballast to apples and biscuits. "Still approaching the sea, we began to strip ourselves." Jeffries reported later. Not until even Blanchard's trousers went overboard did the balloon ascend. After two hours in the air Blanchard and Jeffries landed near Calais, where they received a royal ovation.

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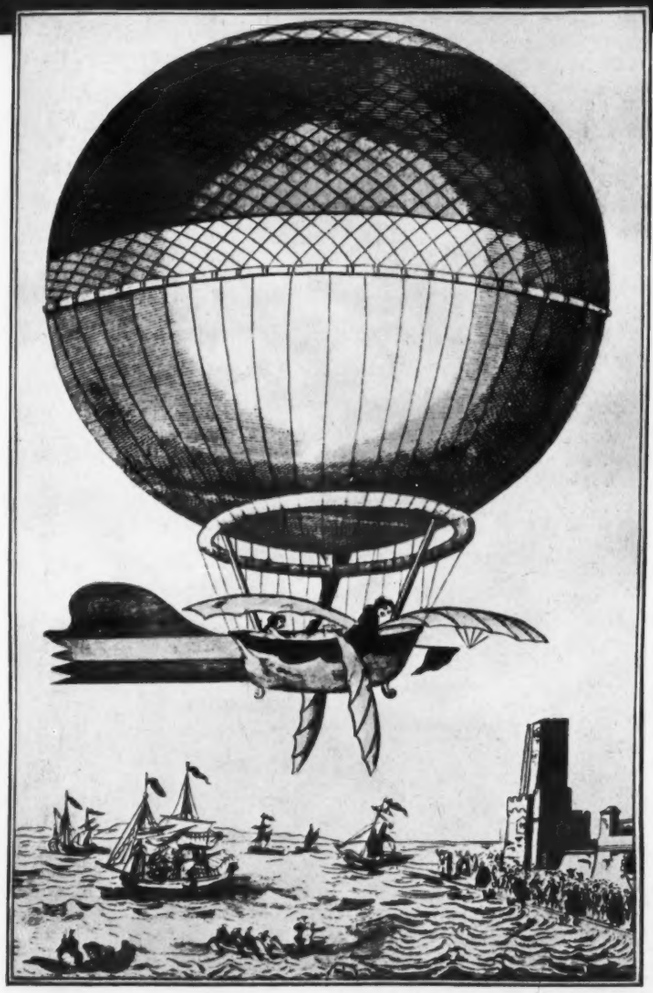

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